The SCIENTIFIC MONTHLY

83 NO. 6 DECEMBER 1956

THE HOW AND WHY OF THE WORLD'S PUREST SILICON

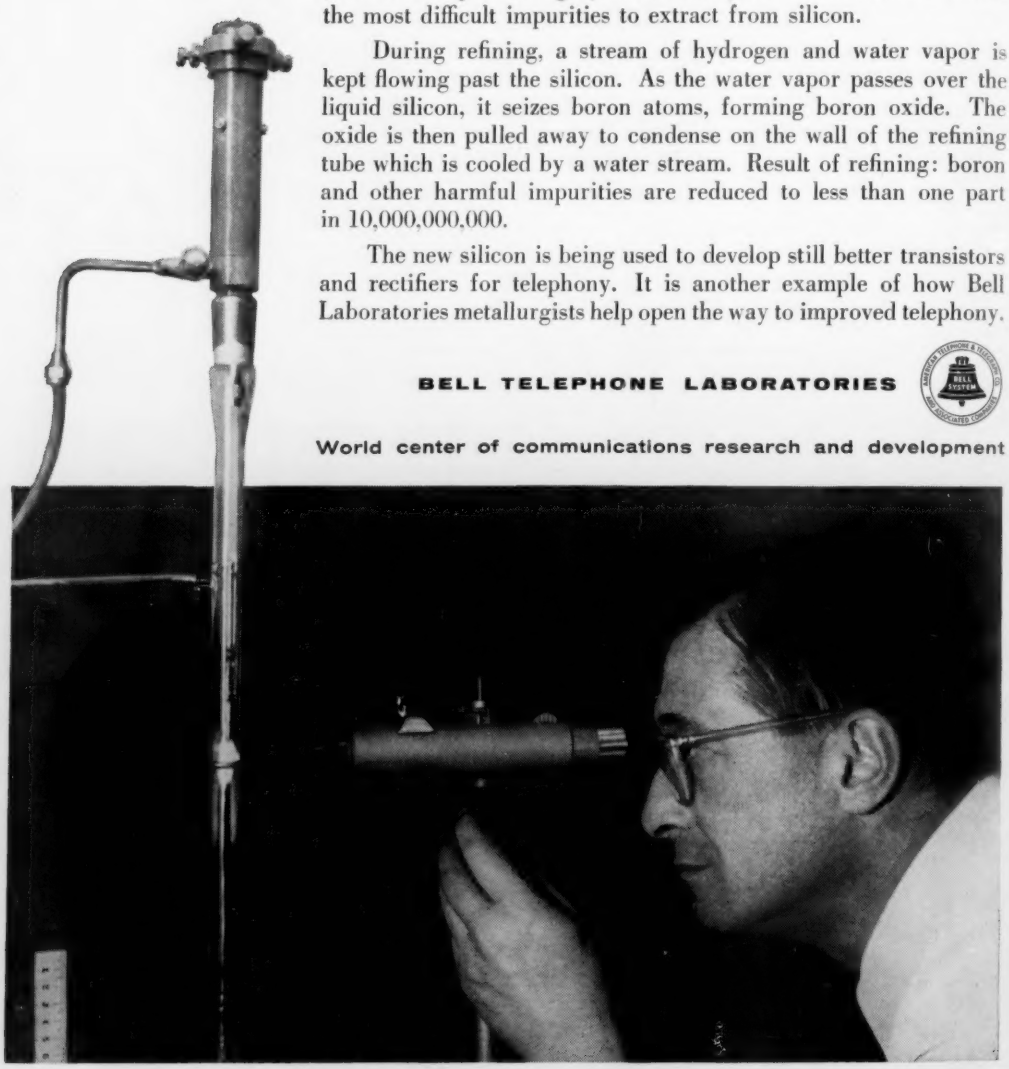
The purification of silicon by Bell Laboratories metallurgists has been richly rewarding. Their original research in this field revealed the chemical factors that control semiconductors; it was a major advance leading to Bell Laboratories' invention and development of transistors and the Bell Solar Battery. Now they have devised a simple but highly effective way to remove boron — one of the most difficult impurities to extract from silicon.

During refining, a stream of hydrogen and water vapor is kept flowing past the silicon. As the water vapor passes over the liquid silicon, it seizes boron atoms, forming boron oxide. The oxide is then pulled away to condense on the wall of the refining tube which is cooled by a water stream. Result of refining: boron and other harmful impurities are reduced to less than one part in 10,000,000,000.

The new silicon is being used to develop still better transistors and rectifiers for telephony. It is another example of how Bell Laboratories metallurgists help open the way to improved telephony.

BELL TELEPHONE LABORATORIES

World center of communications research and development



Metallurgist Henry C. Theuerer, M.A. in Chemistry, Columbia, watches a molten zone in a silicon rod under purification. Mr. Theuerer's most recent achievement was development of water-vapor treatment for removal of boron.

THE SCIENTIFIC MONTHLY

VOL. 83 DECEMBER 1956 NO. 6

Index Issue

Man as a Link in Complex Machine Systems . . . . . *G. H. Mowbray* 269

Genetic Principles in Human Populations . . . . . *H. J. Muller* 277

Some Peaceful Uses of Atomic Energy *W. Kenneth Davis, Shields Warren, Walker L. Cisler* 287

Gravity Program of the U.S. National Committee for the IGY . . . *George P. Woollard* 298

Association Affairs: Proposed Change in AAAS Constitution; Traveling High-School Science Libraries; Moving Frontiers of Science; Some Programs of the New York Meeting 300

Book Reviews of *The Laws of Nature; The Men behind the Space Rockets; Genetics in the Atomic Age; Public Works and Employment from the Local Government Point of View; A Field Guide to the Ferns and Their Related Families of Northeastern and Central North America with a Section on Species also Found in the British Isles and Western Europe; The Condensed Chemical Dictionary; International Encyclopedia of Unified Science; An Essay on the Foundations of Geometry; Investigation on the Theory of the Brownian Movement; Organization of the Federal Government for Scientific Activities; Robert Hooke*; Books Reviewed in *Science*; New Books 310

Cover: Giant Jackstraws

[*Courtesy Wallace R. Brode, National Bureau of Standards, see page 276*]

AAAS EDITORIAL BOARD

GRAHAM DUSHANE, *Editor* CHARLOTTE V. MEETING, *Assistant Editor*

MARK H. ADAMS, WALLACE R. BRODE, BENTLEY GLASS, KARL LARK-HOROVITZ, EDWIN M. LERNER, WILLIAM L. STRAUS, JR.

Advertising Representative: EARL J. SCHERAGO

THE SCIENTIFIC MONTHLY, established in 1872 as *The Popular Science Monthly*, has been an official publication of the American Association for the Advancement of Science since 1915. It is published for the Association at Business Press, Inc., Lancaster, Pa.

Copyright, 1956, by the American Association for the Advancement of Science. Entered at the Lancaster, Pa., Post Office as second class matter under the act of March 3, 1879.

All correspondence should be addressed to THE SCIENTIFIC MONTHLY, 1515 Massachusetts Ave., N.W., Washington 5, D. C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts and photographs or for the statements and opinions expressed by contributors.

Change of address: Four weeks are required to effect a change of address. If possible, please furnish an address stencil label from a recent issue. Be sure to give both old and new addresses, including postal zone numbers, if any.

Annual subscriptions: $7.50, domestic and foreign. Single copies, 75¢. Special rates to members of the AAAS.

THE SCIENTIFIC MONTHLY is indexed in the *Reader's Guide to Periodical Literature*.

The AAAS also publishes SCIENCE. Subscription and advertising rates will be furnished on request.

Science and Technology

All inquiries concerning items listed here should be addressed to The Scientific Monthly, *Room 604, 11 W. 42 St., New York 36, N.Y. Include the name(s) of the manufacturer(s) and the department number(s).*

Comparator

A new impedance comparator compares complex impedances of any phase angle and indicates the difference in magnitude between the two components being compared and the phase-angle difference simultaneously. On the most sensitive ranges the differences can be determined to 0.01 percent and 0.0001 radians, respectively. The unit includes a calibrating voltage, and the internal oscillator provides frequencies from 100 cy/sec to 100 key/sec in decade steps. Meter voltages are available externally to operate recorders, remote indicators, or selecting devices. The range of impedances that can be compared is nominally from 2 ohm to 20 mohm. Four independent ranges are provided for the impedance difference and the phase-angle difference. (General Radio Co., Dept. M26)

Amplifier

Adjacent low- and high-level pulses at high-duty cycles from scintillation detectors, ionization chambers, and other radiation detectors, are amplified by a new linear amplifier. Measurements may be made of the kiloelectron-volt Cs^{137} x-ray peak in the presence of a 1.2×10^6 count/min of Co^{60} background. The apparatus utilizes double-differentiation and feedback stabilization to obtain pulse amplification. (Franklin Electronics Inc., Dept. M25)

Infrared Optical Elements

Technical data on 15 infrared-transmitting materials that are suitable for use as optical elements in infrared equipment are available in a new brochure. (Servo Corp. of America, Dept. M24)

Storage Tube

An information storage tube that incorporates a 1-in.^{2} mesh can store 800,000 information signals. The mesh is a thin sheet of glass in which 250,000 small holes have been etched and filled with metal. Each of these cells is capable of retaining for minutes charges built up in the capacitance between the recessed metal plug and conducting layers that are deposited on either surface of the glass screen. The cells distinguish between ten levels of intensity from the electron-beam scanner that places the signals on the screen. A second scanner collects the signals. (General Electric Co., Dept. M17)

Monitored Demineralizer

A table-model, ion-exchange water demineralizer for direct-faucet connection includes a direct-reading meter that is calibrated in ohms per cubic centimeter and in parts per million to indicate the quality of water being delivered at flow rates of approximately 1 gal/min. (Ion-Exchange Products, Dept. M44)

Pot Still

A new pot-type still utilizes direct agitation of the distillant, and is capable of limited fractionation of organic materials up to a molecular weight of 700. Construction features an all-glass column with a distillate and capacity of up to 2 lit and an output of 1 lit/hr. Vacuums up to 0.1μ of Hg and temperatures up to 300°C can be maintained. The unit includes an oil-diffusion and gas-ballast mechanical pumping system, an electromagnetic stirrer, three condensate receivers, heat control, and a water-cooled condenser and diffusion pump. (Arthur F. Smith Co., Dept. M14)

Isotope Data

An isotope index has been compiled that lists the sources of known commercially available isotopes. Included are stable and radioactive isotopes and a large number of compounds labeled with C^{14}, I^{134}, P^{32}, S^{35}, deuterium, and other isotopes. Chemical name or formula, specific activity, interfering activities, half-life, and principal radiation are given for each of more than 2000 items. The 64-page publication also includes sections on available calibration samples and radiographic and therapeutic sources. (Scientific Equipment Corp., Dept. M21)

Electronics Data

A recently published Electronics-data handbook gives in 64 pages a selected collection of often-needed formulas and data used in radio and industrial electronics. Formulas include those needed for basic circuit analysis, transmission-line calculations, determination of vacuum-tube characteristics, resonance calculations, meter calculations, and so on. (Allied Radio Corp., Dept. M38)

Liquid Dispenser

A new vial filler dispenses up to 8 oz of liquid per stroke and fills vials singly or in multiples of two. Free-flowing or semiviscous fluids, including aqueous solutions, oils, syrups, suspensions, and saturated solutions, may be dispensed at rates variable from 3 to 60 fills per minute. Volume of fill is adjustable from 0.002 oz per stroke on a calibrated micrometer dial. (National Instrument Co., Dept. M40)

Dust-Proof Colorimeter

Color-difference determinations in temperature-sensitive materials and in dusty atmospheres are possible with a newly developed colorimeter. A cooling system and an air filter are provided. The apparatus performs the functions of an abridged spectrophotometer and a tristimulus colorphotometer in analyzing color formulations, determining metameric conditions, and measuring color differences in hue, value, and chroma. (Instrument Development Laboratories, Inc., Dept. M43)

THE SCIENTIFIC MONTHLY

DECEMBER 1956

Man as a Link in Complex Machine Systems

G. H. MOWBRAY

Dr. Mowbray is a senior staff member of the Johns Hopkins University Applied Physics Laboratory, Silver Spring, Maryland. He received his training at Johns Hopkins University and Cambridge University, England, where he was associated with the Medical Research Council Applied Psychology Unit. He returned to this country in 1953 and has since been engaged in research on human problems associated with guided missile systems. The illustrations used in this article were provided through the courtesy of A. Chapanis of Johns Hopkins University.

DURING the last war, many complex machines and machine systems were devised and put into use. They were not always successful, and not because they were poorly conceived or badly constructed. Very often they failed because they demanded more of human operators than human operators could supply. Personnel selection techniques, which were developed to a fairly high degree between the wars, were taxed to the limit to provide the kinds of skilled operators that the new weapons required. One of the major difficulties arose from the fact that the same general abilities were required of operators of all of the new machines. The machines demanded a fairly high level of intelligence, some aptness for things electrical and mechanical as well as some training along those lines. Needless to say, there were not enough of the right kind of people to go around. Training procedures were slow and costly.

It soon became evident that the situation could be eased somewhat if the man's role in man-machine systems were carefully scrutinized with the view in mind of simplifying his task. It was thought that if machines could be designed *by* men, they could likewise be designed *for* men—that is, if advantage were taken of man's inherent capabilities, less time and effort would have to be expended on his training and in cleaning up after his mistakes.

In considering man as a link in complex machine systems, there are different levels from which the problem may be viewed. First there is the rather broad concept of man as a series or parallel link. An example of a man operating as a series link is provided by a radar operator, who serves as a link between the radar itself and another man or other men. Data in terms of space coordinates are taken from the visual display and relayed by voice or by mechanical aids to another man—a pilot perhaps—to be used for navigational purposes. The pilot of an airplane flying on automatic pilot is an example of a man being used as a parallel link. His function is that of a monitor who may override the automatic control at any time but who, at the same time, is free to perform other necessary tasks.

The use of an electro mechanical system to relieve the human being of a boring and routine type of operation is a recommended one. Now, of

course, the danger inherent in using a man in one of these fashions lies in the fact that, unlike a machine that operates as it is designed to operate —unless of course it breaks down—a man may change his mode of operation unpredictably and without warning. What was a moment ago a perfectly adequate series or parallel link may suddenly become a closed link, or a broken link. Before this disadvantage can be overcome completely, much more will have to be learned about human stress, fatigue, and motivation.

The analogy between man and a servomotor has often been made, and justifiably so, I think. Let us return for a moment to our airplane pilot who is such a good example of so many things. In essence, when he is flying his plane, he is acting as a servo. He receives information from his instruments, from the sound of his engine, and from the general feel of the aircraft. He translates these inputs into corrective actions whose results are fed back in return.

The quite complex task of controlling the attitude of an aircraft in heading, bank, and pitch is successfully accomplished thousands of times each day. However, long hours of practice are required before a man can become proficient at this sort of thing. It has been suggested that training time could be reduced and the pilot's task made less complex by the simple expedient of providing him with immediate knowledge of the effect of his control corrections (*1*). Man's responses in a control system are not continuous but intermittent. The man perceives that a correction is required; he then introduces a correction and waits for his instruments to tell him that the correction has been sufficient. An appreciable lag between the correction and the indication will cause overshooting and a more or less continuous oscillation or instability. Lags of as little as 40 milliseconds, even though they are not detected by the operators, have been shown to affect performance adversely (*2*). Much longer lags than this are found in some control systems.

The fact that man responds intermittently and not continuously is important to the design of control systems in another way. When he is operating controls that require continuous correction, as in tracking a moving target or in steering an automobile, a man exhibits a natural oscillation of about ½ cycle per second (*3*). To put a man in any system that has an independent, resonant frequency in this range is to invite amplification of these oscillations, with possible dire consequences.

The second level from which the problem under discussion may be considered deals with more specific things. To begin with, the human being may be looked upon as a link between displays and controls. He receives an input from a display or a group of displays, interprets the information provided, and selects the proper response. Usually his response is made effective through some system of controls. It becomes evident at this point that the proper design of displays and controls is important.

Design of Instrument Displays

From almost any standpoint by which one may wish to consider it, we obtain most of our information from the world about us through the medium of our eyes. This is true for the machine operators in industry, for the pilot of an aircraft in the military service, or for anyone engaged in the ordinary pursuits of everyday existence. For this reason visual displays whose purpose is to convey information are important, whether they are for such specialized tasks as driving a truck, piloting an aircraft, or controlling airport traffic, or for less specialized pursuits such as advertising or education. If they fail to convey information because of ambiguity, illegibility, or whatever cause, they may be art, but they are no longer visual displays in the sense that I mean.

In the main, industry and the military services are concerned with displays for specialized tasks, and since these displays are usually visual displays, I intend to concentrate on that aspect of the problem. These displays very often, though not always, take the form of dials such as speedometers, pressure gages, altimeters, and the like. Generally, it is important that the information they convey be readily interpretable—speedily and accurately. Therefore, it is vital to know something about the perceptual capacities of those who are going to interpret them in order to design them so that they can be read quickly and without error.

Instrument dials, which are the type of display I want to talk about mainly, can be divided roughly into three categories. First, there are those that are used for check readings; that is, they usually give "either-or" information and are used to tell an operator that something is "on" or "off" —working or not working. Or they may be used as warning devices.

Second are the qualitative instruments. These usually indicate the state of something, with the addition of a directional component. Many dials designed for more quantitative purposes are often used by the operator merely for the qualitative information they provide. One example that I know of concerns the manifold pressure gage and

cylinder head temperature gage in certain types of aircraft. Pilots report that their instruments give much more precise indications than they ever need or use. All they want to know is whether the readings are reasonable and to be able to see when they begin to go off.

The third type of instrument is the most common one and the most important one, for it provides the operator with fairly precise quantitative information that can be vital to his needs in many situations. When dials of this sort have to be read quickly and accurately, their design is particularly important.

A quantitative dial that is extremely vital in airplanes is the altimeter. Failure to read this properly can lead to disaster. Some years back a survey was made of dial-reading errors among Air Force pilots, and one result of this investigation was the finding that the three-pointer altimeter was about the most difficult aircraft instrument to read correctly (*4*).

Figure 1 shows clearly the conventional three-pointer altimeter and one type of reading error that is extremely common with it. In reading this dial, the short, thin hand denotes units of 10,000 feet or fractions thereof, the next shortest but broadest hand points to units of 1000 feet, while the longest hand indicates the hundreds. Therefore, in Fig. 1, the small hand is showing less than 10,000 feet or somewhere between 6000 and 8000 feet, the broad hand points to 7000 feet, but the long hand shows less than 1000 feet, or 960 feet to be exact; thus the dial indicates a correct reading of 6960 feet. It is not difficult to see how an error of 1000 feet could be made.

A carefully controlled experiment with 97 experienced pilots and 79 male college students showed that in reading altimeter settings at rapid rates the pilots made errors of 1000 feet or more about 12 percent of the time and college students about 17 percent of the time (*5*). As a follow-up, five different types of altimeters were designed and tested similarly. All five proved to be better than the one in use in terms of time taken to read and number of reading errors committed. The instrument that fared the best—and this is not surprising, of course—was a direct-reading counter (*6*). However, it is mechanically impractical to devise such an instrument for this particular use. However, another instrument that was only slightly worse than the direct-reading counter was the combination of a single multirevolution hand and a direct-reading counter. The altitude in thousands of feets was given by the counter, and the single hand denoted the hundreds.

The development of such an altimeter that would operate directly on barometric pressure did not prove to be easy. The first attempts were not altogether successful, since an absolutely foolproof instrument was required—one that could not become inoperative owing to mechanical or electric failure. Much time and effort (nearly 5 years, in fact) have resulted at last in success. This type of instrument is now being produced commercially and will probably supersede the conventional three-pointer type in time.

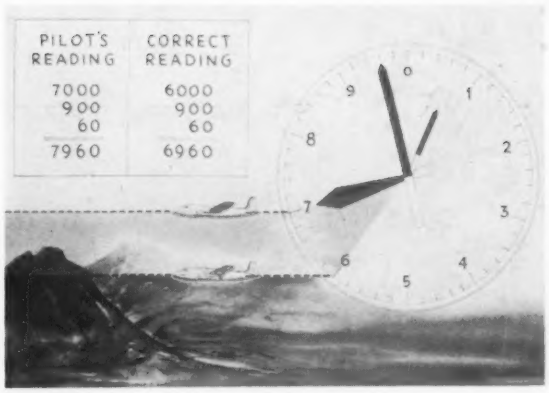


Fig. 1. A typical aircraft altimeter showing a common reading error to which this instrument is subject.

If one stops to think about the design of instrument dials, one is immediately impressed by the number of ways they can be varied. Size, shape, size of scale interval, type of scale (linear, logarithmic, and so forth), type of lettering, type of pointer—these are only some of the ways. The effect of all these factors has been studied in a more or less systematic fashion, and to review them all here would take more space than I have at my disposal. There are three that I do want to mention briefly, however. These are the effect of the size of the marked scale interval on the accuracy of reading, how scale numbering affects the accuracy, and the effect of different dial shapes on accuracy of interpretation.

There are three perceptual steps that are involved in reading a dial scale when interpolation between marked intervals is required. For example, it does not take long to decide that a pointer is somewhere between 2 and 3 when the scale is marked off in five units. It takes a little longer to see that the pointer is between 2.0 and 2.5. Often this is enough accuracy to suit anyone, but occasionally it is necessary to interpolate a little more closely. The problem at hand, then, is to know just how the distance between the marked intervals affects accuracy of interpolation. An experiment on just this problem was performed, and

Fig. 2. Relative and absolute error of interpolation between marked intervals as a function of the size of the marked interval.

the results are shown in Fig. 2 (*7*). Here the relative error is the error expressed as a percentage of the marked interval, while absolute error is the actual error expressed in millimeters. It is evident that for very small scale intervals the relative error is large, while the absolute error is small, and that as the size of the scale interval increases the relative error decreases until, for a separation of 10 millimeters, it reaches a minimum and stays there. The absolute error, however, continues to increase. This relation holds, incidentally, over a very wide range of dial sizes. The inference to be drawn from these results, then, is that no advantage, in terms of accuracy of interpolation, is to be gained from marked intervals larger than 10 millimeters, but that intervals smaller are likely to result in an increase in the size of the error considered as a percentage of the marked interval.

Researchers in England some years back made a thorough study of the accuracy with which persons could read dials with different numbering systems (*8*). No purpose would be served in presenting all the detailed and complicated findings of this research. In general, it was reported that scale numbers that are decimals, as opposed to whole numbers, are harder to work with than those that are not. The best scale numbers are whole numbers that are divisible by 10—1000, 100, 10, and so on—whereas scale intervals in 4's are the most difficult. Finally, and not surprisingly, it was found that 8 and 16 scale units between numbered markers are hard to read, but 2 scale units between numbered markers are easy if enough room is left between them.

There is, of course, nothing very profound in these results, but one does not have to search far anywhere today to find scales that violate these principles.

Another important consideration in dial design is the shape of the dial. Shall it be circular, rectangular, semicircular, or what? Figure 3 shows the results of an experiment in which five dial shapes were tested for single-revolution dials (*9*). In this research, observers were forced by appropriate procedures to read the dials very rapidly. It can be seen that by far the most superior display was the open-window one at the bottom where, out of a total of 1020 readings, only five were in error. It should be pointed out here that the open-window dial is not necessarily the best

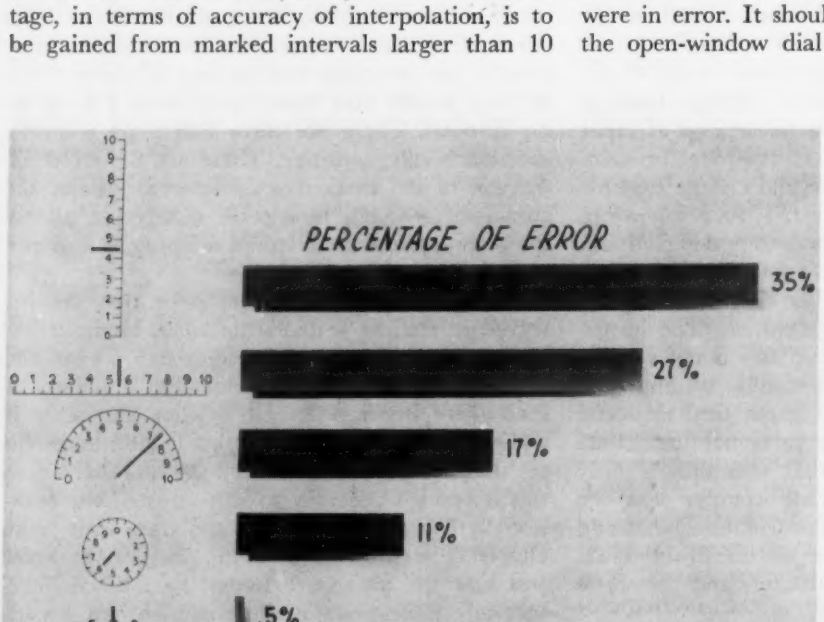


Fig. 3. Percentage of error in reading dial settings as affected by the type of scale.

dial for all conditions. In situations where ample reading time is allowed, or where the scale or pointer is not static but is moving, other types of dials would give optimum results.

Design of Controls

So much for the input side to our human link. Equally as important is the output or control aspect of the problem. To convince oneself how vital that part is, all one needs to do is look into the cockpit of any modern commercial airliner. Air Force psychologists have been concerned with this problem for a long time, and much useful knowledge has come from their researches and surveys. Pilot errors in one study were found to be caused by confusion of controls in many cases (*10*). The responsible factors were the crowding of controls and nonstandardization of control shapes and locations from plane to plane. Another type of error resulted from the fact that sequences of control adjustments were too complicated and, in emergencies, improper sequences were used, or portions of sequences were forgotten. Finally, reversal errors were frequently made. That is, a pilot moved a control in the opposite direction from that which he intended. Superficially, this might be considered the pilot's fault, but it has been established that there are "natural" directions of movement for controls and, under stress, people are likely to revert to these natural tendencies. If an important control is designed to operate in opposition to these principles, only trouble can be expected in the long run. In those cases where there may be no preferred direction or pattern of movement, another principle has been shown to operate. It has a technical name that need not concern us here, but, in brief, a statement of the principle is this: If a new motor-coordination pattern is learned in the course of learning a new skill, and if, later, for some reason, that pattern has to be altered slightly to conform to a new development, then, should an emergency arise, the tendency to revert to the pattern learned earlier is very compelling. I am sure that most people have experienced the operation of this principle to some degree. How many have been embarrassed to find themselves pumping air with their left foot the first time they had to make a sudden stop after getting behind the wheel of an automobile with automatic transmission? Such behavior, to be sure, seldom results in anything more tragic than a red face. However, more serious consequences could result from other circumstances. Many pilots who learned to fly in planes that had the flap controls on the right and the landing gear controls on the left have never lived to regret the day that they transferred to a plane with the flap controls on the left and the landing-gear controls on the right.

As in the case of visual displays, I can only give here a very superficial coverage to the sorts of things psychologists are doing to improve controls. Much work has gone into establishing the preferred directions of control movements (*11*). Indications point to the fact that a toggle switch should flip *up* for ON, GO, or INCREASE, and *down* for OFF, STOP, or DECREASE. Similarly, levers whose motion is in the horizontal plane should go *away* from the operator for ON, GO or INCREASE, and *toward* the operator for OFF, STOP, or DECREASE. In the case of handwheel controls associated with a visual display, clockwise movements of the wheel should move displays downward if the display is to the right of the handwheel, and upward if the display is to the left. The reverse should be true of counterclockwise movements.

Another problem that arises when a control is used in conjunction with a visual display concerns the optimum gear ratio for the movement of an indicator. Experiments on this problem point to the fact that, when speed is the prime objective, the task can be broken down into three components. First is the reaction time—the time that it takes to get moving. This turns out to be a constant factor. A second consideration is what may be called primary movement time—the time required to move the indicator to the correct vicinity. The third factor can be termed secondary

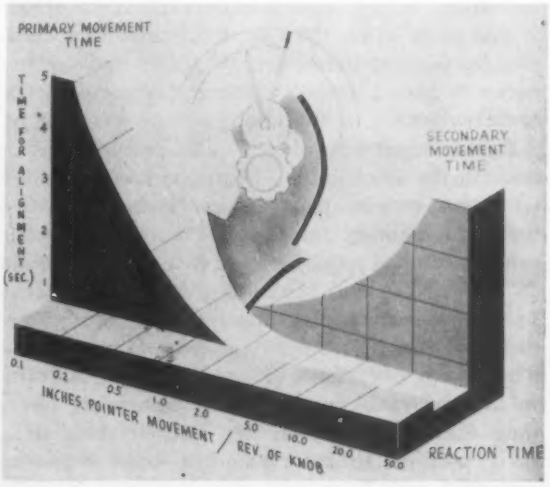


Fig. 4. Contribution of reaction time, and primary and secondary movement times to the alignment time of a pointer as a function of the gear ratio of the control knob.

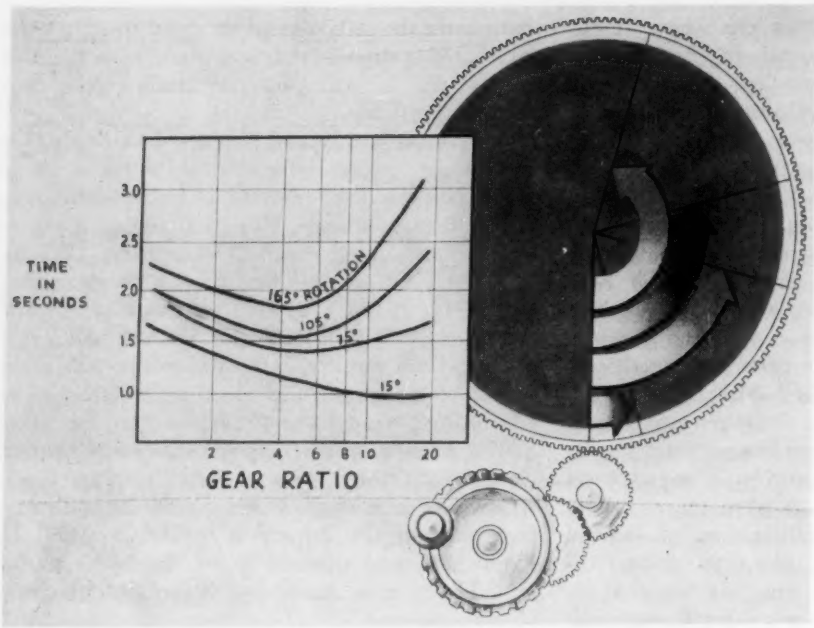


Fig. 5. Time in seconds required to slew a cursor through various degrees of rotation as a function of the gear ratio used.

movement time or adjustment time, and, as one might expect, this is the time required for fine corrective movements once the indicator is in the right vicinity. Figure 4 shows how these three factors contribute to alignment time as a function of the gear ratios used (*12*). Here it is seen that if a pointer is geared to move only a small amount for each revolution of a knob, primary movement time is long; on the other hand, primary movement time is short if the pointer movement is large for each revolution of the knob. Secondary movement times, it appears, are almost the inverse of primary movement times. The best over-all ratio occurs at that point where the sum of the three time components is at a minimum, or about midway between 1 and 2 inches of pointer movement for each revolution of the knob.

Still another type of gear-ratio problem has to do with the mechanical cursor that is encountered on many remote plan-position radar indicators used with military equipment. Figure 5 shows the time in seconds required to slew a cursor through 15°, 75°, 105°, and 165° using various gear ratios (*13*). It seems clear cut that for excursions greater than 75° there is an optimum gear ratio of about 5 to 1. For excursions of less than 75°, the optimum gear ratio appears to be somewhat larger than that. However, on the basis of these data, it is possible to recommend a compromise at around 5 to 1, since the gain in time for higher gear ratios and lower degrees of excursion is not appreciable.

The optimum rates of control movements are determined in part by such factors as the maximum rate of muscle contraction, the maximum rate of innervation, and the effect of fatigue. High rates of movement are commonly required by handwheel controls. Winding movements are a combination of reciprocal movements properly distributed in phase. Their maximum rate is approximately half that of simple back-and-forth movements of similar amplitude. The rate that results in most accurate control depends on handwheel diameter, inertia, friction, and other design features. Experiments have been done to show how cranking speed is affected by crank radius and friction-loading of the crank (*12*). Two things have been demonstrated. One is that for every crank loading there is an optimum crank radius, and second, that as the friction-loading of the handwheel increases, the optimum radius likewise increases slightly. Figure 6 is an illustration of the way handwheel tracking accuracy increases as a function of the speed of handwheel turning. This function was measured for a crank radius of 4.5 inches. In this case, the operator's task was to follow a constantly moving target with an indicator spot whose motion was controlled by a handwheel. The target speed was held constant, but the rate of turning required to keep up with the target was variable. The error, measured in time units, was proportional to the distance the operator was ahead of or behind the moving target. As can be seen, accuracy improved steadily with increasing

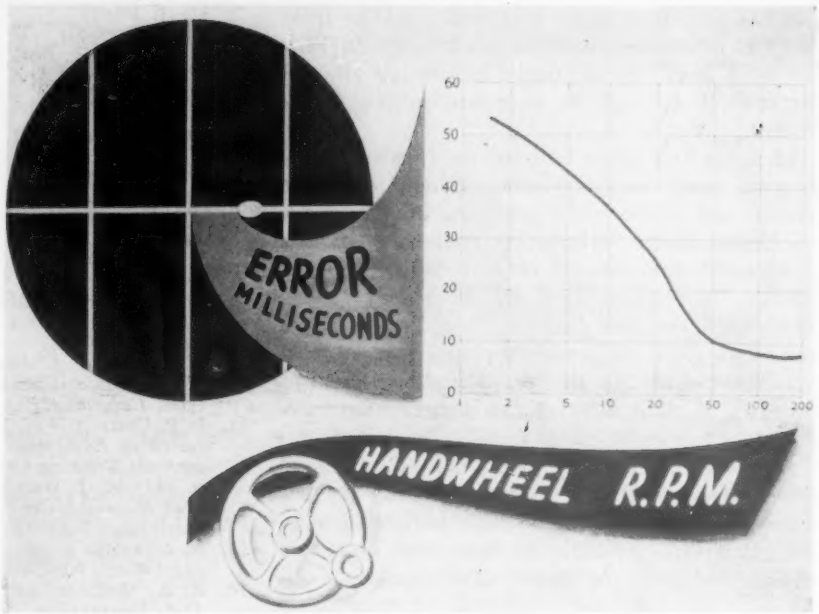


Fig. 6. Error in handwheel tracking for various speeds of handwheel rotation. The time error corresponds to the distance that the tracker is ahead of or behind a moving target.

handwheel speeds. These results provide some fairly general principles that can be applied to the area of handwheel tracking.

Since confusion of controls has been shown to be one of the prime causes of errors, particularly where pilots are concerned, much research has gone into ways of avoiding such confusion. Different methods of control coding have been extensively investigated, and some general conclusions can be stated.

It has proved possible to shape code controls—that is, to design knobs with different shapes that can be immediately discriminated even when the operator has gloves on (*14*). If some standardization were adopted so that similar functions on different pieces of equipment had control knobs of the same shape, training problems would be easier, and less confusion would result.

Extensive studies have been made on the ability of people to reach, without looking, and operate controls—beside them, above them, behind them, and so forth. If a high degree of accuracy is required, it is best to arrange the controls in a vertical row at shoulder level. A safe distance between these controls is 5 inches (*12*).

Color coding is another aspect that has been studied very thoroughly. The number of discriminable colors, if one includes all hues with varying degrees of saturation and various degrees of lightness and darkness, is probably greater than 300,000. However, in the practical situation, the operator has neither the time nor the inclination to identify colors by comparison; rather he must be able to identify the colors in an absolute sense. Estimates of the number of such absolutely identifiable colors suggest that there are no more than ten or 12 where spectral hues are concerned (*15*). However, there are many disadvantages to using color for coding controls. For example, many colors already have meaning attached to them—red, green, yellow for danger, go, and caution, for example. Also the amount of illumination available and the type of illumination greatly affects the way colors are seen. These things are not always easy to control.

As I stated before, there is much more to the design of controls than I have been able to indicate here. Very important areas have not even been mentioned, but I hope that at least some of the flavor of the work of psychologists engaged in equipment design has been imparted. By continuing effort, we hope to be able to increase the efficiency with which operators can perform their tasks and at the same time relieve them of some of the strain that they have often suffered in the past in trying to pursue their duties.

I wish to point out in closing that too often, in the past, the human component has been overlooked in the original design. The engineer has taken advantage of man's flexibility to fill a function that could not be produced readily with an electronic or mechanical component. The man has been put into the system as a glue to hold it together. At best, consideration of human fac-

tors has often been given a secondary role by most designers of equipment. This is not surprising, for the same flexibility mentioned before has allowed the man to be used as a general purpose component.

Men can talk, push buttons, use handcranks or joysticks, and do many other things. All these outputs are usable and have been used in man-machine systems. It must be remembered that man's motor performance characteristics vary considerably, depending upon the mode of response. The design engineer can use these characteristics in two ways: (i) to provide those movement characteristics which are desired as input to controls and (ii) to eliminate those movement characteristics that are undesirable.

It is well to remember occasionally that, for all the automation that is being predicted for the future, somewhere along the line will be a man. To exploit his versatility is both wise and economical, whereas to ignore his limitations is inefficient and could be disastrous.

References

1. H. P. Birmingham and F. V. Taylor, *U.S. Naval Research Lab. Rept. No. 433* (1954).
2. M. J. Warrick, *U.S. Air Force Tech. Rept. No. 5916* (1949).
3. K. J. W. Craik, *Brit. J. Psychol.* **38**, 56, 142 (1948); W. E. Hick and J. A. V. Bates, *Great Brit. Ministry of Supply Monogr. No. 17204* (1950).
4. P. M. Fitts and R. E. Jones, *Aero Med. Lab. Air Materiel Command Rept. No. TSEAA-694-12A* (1947).
5. W. F. Grether, *Air Materiel Command Rept. No. MCREXD-694-14A* (1948).
6. ———, *Air Materiel Command Rept. No. TSEAA-694-14* (1947).
7. W. R. Garner and J. W. Gebhard, *Machine Design* (Aug. 1949).
8. M. D. Vernon, *Med. Research Council (Brit.) Appl. Psychol. Unit, Cambridge Univ., Rept. No. APU 49* (1946).
9. R. B. Sleight, *J. Appl. Psychol.* **32**, 170 (1948).
10. P. M. Fitts and R. E. Jones, *Engrg. Div. Air Materiel Command Rept. No. TSEAA-694-12* (1947).
11. L. F. Carter and N. L. Murray, in *Psychological Research on Equipment Design*, P. M. Fitts, Ed. (Government Printing Office, Washington, D.C., 1947), p. 147; M. J. Warrick, *ibid.*, p. 137; M. A. Vince, *Med. Research Council (Brit.) Appl. Psychol. Unit, Cambridge Univ., Rept. No. APU 125* (1950).
12. A. Chapanis *et al.*, *Applied Experimental Psychology* (Wiley, New York, 1949).
13. R. A. McCleary and C. T. Morgan, *Psychol. Lab. Inst. Cooperative Research, Johns Hopkins Univ., Rept. No. 166–I–96* (1949).
14. W. O. Jenkins, in *Psychological Research on Equipment Design*, P. M. Fitts, Ed. (Government Printing Office, Washington, D.C., 1947) p. 199.
15. R. M. Halsey and A. Chapanis, *J. Optical Soc. Amer.* **41**, 1057 (1951).

Giant Jackstraws

The giant jackstraws photographed on our cover this month are actually wooden dowel pins, each about 18 inches long and ½ inch in diameter, for furniture. Here they are being cured by air drying after having been dumped from the dowel-pin machine. The picture was made by Wallace R. Brode, National Bureau of Standards, Washington, D.C., in the yard of a New England wood-turning mill.

Genetic Principles in Human Populations

H. J. MULLER

Dr. Muller is professor of zoology at Indiana University. An address that Dr. Muller delivered at the symposium on "Recent progress in genetics and its implications for psychiatric theory" on 2 May at the 112th annual meeting of the American Psychiatric Association in Chicago, Ill., was based on this paper, which is being published simultaneously in the American Journal of Psychiatry (*1*).

THE heredity - environment controversy, which had already been raging for a long time in my student days a half century ago, is an excellent example of wishful thinking by two sets of fanatical opponents, both of whom ought to know better.

Heredity and Environment

It is of course absurd to deny the influence of environment in giving rise to alterations in living things. Its importance is illustrated by the fact that life is sometimes defined as a continual adjustment of inner to outer conditions. Now, although this definition misses the main point, such adjustment is certainly characteristic of living things. Moreover, the higher they are the more applicable is the statement. Thus, the most advanced system in the most advanced organism, namely, the central nervous system in ourselves, has this kind of adjustment as its primary function. In consequence, it achieves a degree of plasticity of response far exceeding that of anything else we know of. We must admit that in this sense its reactions are determined in great detail by its surroundings. And yet we also know that the human organization, including that of its nervous system, is a superlatively intricate one, more intricate than any other known structure. Thus its capacity to carry out these varied reactions, and the exact form taken by them, depend not only on its past and present environment but also on what complexities of inner constitution have been provided by its long prior course of evolution and by its more immediate circumstances of ancestry.

It follows that nongenetic conditions, for their part, can determine such enormous differences in response as those between the civilized man and the savage, and those between the normal man and the victim of polio, of oxygen deprivation at birth, or of a sadistic foster father. On the other hand, heredity, for its part, can predetermine such differences as those between a man and a fish, and those between a normal man and a sufferer from anencephaly, phenylpyruvic amentia, or Huntington's chorea. Moreover, even abnormalities which appear to the superficial observer to be of exactly the same kind, such as a grossly underweight condition in two different persons, or a strikingly deformed cranium, or an apathetic disposition, may in one case be traced to imposed conditions of living and in another case to peculiarities of the biological inheritance.

Today, although few people would deny that differences as gross as those just mentioned can be caused by either environment or heredity, opinion tends to fall into two camps with regard to the causation of the smaller differences, especially those within the range vaguely delimited as "normal." Yet we all know that, so far as environmental effects are concerned, the lesser deviations from the mean are more numerous than the more extreme ones and that the effects tend in general to follow a normal curve of frequency distribution. Similarly, studies in heredity have shown that, when any measurable characteristic is considered, the mutations causing smaller deviations (many of them quite invisible) arise more frequently than the so-called large mutations. Moreover, the larger the effect of the mutation the more harmful is it likely to be and the smaller, in consequence, will be the number of descendants to whom it will be passed down. For these two reasons together, the hereditary effects, like the environmental ones, will tend to give rise to a more or less normal curve in the case of most quantitatively varying traits. The observed curve will of course be a resultant of both the environmental and genetic variations acting together in a more or less cumulative although far from strictly additive manner.

What proportion of the differences depends on hereditary rather than environmental causes is a matter that varies widely according to the trait

under consideration, the genetic nature of the population, and the existing environmental complex. For example, the skin color variations seen in Harlem, New York City, are mainly genetic, while those seen on the beach at, say Brighton, England, are mainly caused by differences in exposure to sunlight. Each problem, then, requires separate assessment, on the basis of empirical evidence. The task is especially difficult when, as in the case of mental traits, given types of cultural and material environments that may influence the result tend to be handed down in families, thus confusing the estimate of what is contributed by biological inheritance.

This is not the place to describe the method of attack on this difficulty that is provided by a comparison of the differences shown by identical twins, fraternal twins, ordinary sibs, and unrelated individuals of the same population, respectively, and also by data on twins or sibs reared apart or differently and on unrelated as compared with related persons reared together. Suffice it to say that, despite the cogent criticisms raised by Price (*2*), by Neel and Schull (*3*), and by others against certain of the simplifying assumptions of the studies of twins, they give results for mental traits in reasonably good accord with those otherwise arrived at, as for instance by the studies on foster children. Thus, for those features of intelligence that are measured by Binet tests, it may be concluded that in middle-class American communities the hereditary contribution to the variance is commonly about double that of the environment.

In this connection, it is to be observed that the tendency of one fetus to gain an advantage over the other is usually stronger for identical than for fraternal twins because of their closer association and greater tendency to mirror imaging. Hence this factor, which appears to be the most important one interfering with a simple interpretation of comparisons between identical and fraternal twin differences, acts to decrease the resemblances between identical twins more than those between fraternal twins. It thereby leads to an underrating rather than an exaggeration of the influence of heredity, as gauged by the twin method. On the other hand, the main influence which seems to act in the opposite direction, the greater tendency of identical twins, because of their likeness, to be treated more nearly alike and to adopt more similar environments, does not entirely constitute a methodological fault. For heredity always acts, in part, by influencing the selection (and in fact the creation) of the environment of the given individual. That is, this ecological channel is an admitted and important path of action of some hereditary differences, in nontwins as well as in twins, and the results of this type of action are not ordinarily to be separated from those of the more direct operations of the hereditary mechanism.

It is important to realize that, however great the influence of environment may be upon the structure and functioning of the organism, the modifications thereby arising do not result in corresponding changes in the hereditary material. They therefore fail to be transmitted germinally. It would take us too far afield to demonstrate here that the archaic folk belief in the inheritance of acquired characters, which goes by the name of Lamarck since he espoused it as the method of evolution, is entirely irreconcilable with the fundamental genetic principles of accurate gene segregation and reduplication and with the fortuitous microdistribution of mutations. Nor can we review the numerous direct tests of this matter. No doubt it was largely the false promise of easy progress offered by the Lamarckian doctrine that led to its repeated revival by nongeneticists having special pleadings to make in regard to problems of the mind or nervous system, such as Driesch and Semon (who based their belief on a cellular psyche), MacDougal (whose results were discredited by those of Crew in a repetition of the experiments), and Pavlov (who subsequently discovered and admitted that his work had been technically faulty). Later, Stalin the omniscient, using Lysenko as his mouthpiece, made Lamarckism, under the title Michurinism, the basis of all Communist biology. However, in view of the "resignation" of Lysenko, announced only a short time ago, there will probably be a considerable interim before another claimant arises to herald his discovery of new proof of this doctrine. In the meanwhile, it is high time for all those in fields affected by these matters to adjust their outlook, if they have not already done so, to the modern genetic conceptions of heredity and variation.

How the Hereditary Cards Are Shuffled

According to modern genetics, each of the 23 different chromosomes present in a mature human sperm or egg cell is differentiated along the length of its coiled thread of polymerized nucleic acid into hundreds of functionally distinct regions, which are denoted by the geneticist as "genes." After union of the egg and sperm nuclei at fertilization, there are two of these sets of 23 chromosomes present. We say that these 46 chromosomes constitute 23 pairs because each of the 23 chromosomes from the mother is matched by a homologous or partner

chromosome from the father. This partner contains corresponding genes that are ordinarily arranged in line within it in just the same sequence, with the exception of a portion of the pair of chromosomes that differentiates the sexes. Although the corresponding or *allelic* genes, those that occupy the same position in line in two homologous chromosomes, are often of identical composition, there are always some genes here and there which are not just like their alleles in the partner chromosome. Partner chromosomes present these differences because they have been derived from different parents, and no pair of parents, taken from heterogeneously breeding population, are of absolutely identical gene content.

Before we consider the past and future history of these gene differences in the population, let us review some other essentials of gene and chromosome behavior. The most remarkable faculty of each gene lies in the fact that it constructs a duplicate of itself, an act that forms the basis of all growth and reproduction. That is, the gene collects, next to itself, scattered bits of given raw materials that lie about it in the nuclear fluid, rearranging them and binding them together into a pattern identical with its own. As this happens all along the chain of genes that forms each chromosome, the consequence is that in place of each original chromosome there now appear to be two of them, as if it had split in half, although the process was really that of multiplication, not division, by two. Since at the ensuing cell division the two members of each of the 46 chromosome doublets are pulled into opposite daughter cells, it follows that each of these cells gets to have a representative of each of the 46 chromosomes that the original cell had had, and of every gene within each of these 46 chromosomes. As this process of precise doubling and apportionment takes place at each of the successive divisions of the fertilized egg and of the body derived from it, all the cells in the body proper may be expected to contain in their nuclei both original sets of chromosomes, 23 in each set, and all their included genes, those derived from both parents. (There is, however, some possibility of certain systematic gene changes associated with the differentiation of somatic cells—a matter as yet uncertain—and, as we shall see, there is always a chance for the occurrence of occasional random mutations during the multiplication of the body cells.)

Now since a person is derived from an egg and a sperm cell each of which contained but one set of 23 chromosomes, the two sets of chromosomes, 46 in all, present in any person's cells must somehow become reduced to one set of 23 again during the process of maturation of his own germ cells to form eggs or sperm, in preparation for the next act of fertilization. This happens through the physical coming together, or *synapsis*, of all partner or homologous chromosomes, two by two, in parallel arrangement with all corresponding genes apposed, followed by the apposed members being pulled or *segregated* to opposite daughter cells, in a cell division that has not been preceded by chromosome doubling. If in the case of a given pair of partner chromosomes the maternal member—that originally derived from the person's mother—chances to be pulled to a given daughter cell that is to become a sperm, it is purely a matter of chance, with equal probabilities of occurrence, whether the maternal or the paternal member of any other pair will be pulled into that same cell. Thus, although the mature germ cell (sperm or egg) comes to contain just one complete set of chromosomes, that set is not derived in its entirety from either the father or the mother of that individual (or, as we may say, the grandfather or the grandmother of the prospective offspring), but is a mosaic, or recombinant, derived partly from each.

The mosaicism or recombination is on an even finer scale of subdivision than the account given thus far would indicate, however. This is because, before the partner chromosomes separate, they have engaged in a curious exchange of corresponding pieces, that is known as crossing over. This involves a breakage of the two homologous chromosome threads at one or more exactly corresponding points and a criss-cross joining together of the pieces. If the fingers of one hand were to represent one set of (only 5) chromosomes, it would be much as though a given finger of one hand had had its end replaced by the corresponding end of that finger of the other hand, and vice versa, in a kind of mutual transplantation process. Sometimes the pieces transferred are longer, sometimes they are shorter, and sometimes they are sections from the middle instead of the end. In consequence of all this, the complete set of 23 chromosomes present in each germ cell constitutes a rather intricate mosaic work, or recombination, of the two sets that had been contributed to the fertilized egg a whole generation previously.

It follows from this series of events that any individual gene is represented only once in the mature germ-cell's set, being either the original maternal gene, now to be called grandmaternal, or the corresponding but perhaps somewhat different grandpaternal one. This may be called Mendel's first law. If now a mature germ cell happens to contain a given gene of grandmaternal origin, then the chance that it will also contain some other

grandmaternal gene that lies in a different chromosome, rather than the corresponding grandpaternal one, will be just 50 percent. This is the basis of Mendel's second law. However, if that other grandmaternal gene, instead of lying in a different chromosome, happens to be one that lies in the same chromosome as the first grandmaternal gene under consideration, it will inevitably come to be included in the same mature germ cell with the first one except in those cases in which the pair of chromosomes in question has undergone breakage and crossing over *between* the points at which these genes are located. The chance for just this exchange to occur is usually less than 50 percent, and it is evident that the nearer together in the chromosomes the two genes in question are placed, the smaller will be the frequency of cases in which they happen to become separated in this way. The genes are then said to be *linked,* and a study of the frequency of their separation in heredity, carried out by tabulating the characteristics of the offspring, allows an estimate to be made of the relative positions of the genes in question in the chromosome. By this method, the so-called chromosome maps have been drawn up. They are not mere speculations. Their physical validity has been verified in a number of ways by direct microscopic observation, even though the genes themselves are too small to be distinguishable by the highest power that it is practicable to use.

The biological function of the whole complicated process of sexual reproduction, including fertilization, the operation of Mendel's laws of segregation, and crossing over—that is, the advantage of this system of events to the species—lies in the mosaic genetic patterns it furnishes. In other words, the important thing here is the provision, in successive generations, of individuals having diverse combinations of the genes in regard to which the individuals of earlier generations had differed. For in the testing out of these varied combinations in the trials of life, some prove to be better able than the average to survive and multiply under given conditions, and in the course of many generations those favored combinations will tend, under those conditions, to crowd out the earlier genetic combinations. Thus the population will have evolved.

Mutations and Their Consequences

It is evident that the formation of these new combinations is dependent on the preexistence of differences between the corresponding genes of different individuals. These gene differences have not themselves arisen by the formation of new combinations of genes, however. They come about by sporadic changes of chemical composition, called mutations, that usually occur pointwise, within a single gene at a time, in a single cell at a time. The mutation is in a sense an accident on an ultramicroscopic scale, involving the collision of a gene with some potent chemical particle or bolt of radiation. The changed or mutant gene is in the great majority of cases impaired in its functioning, inasmuch as the change was not Lamarckian—that is, it was not the result of an adaptive reaction. For blind changes made in any complicated organization are nearly always harmful. Very rarely, however, the modification of gene functioning will happen by a fortunate accident to be of an advantageous nature; at least it may have an advantageous effect under given circumstances. It is only because of the occurrence of these occasional mutations of a potentially beneficial kind that sexual reproduction, by giving new combinations of these mutant genes, serves to promote evolution. All this implies, of course, that the mutant gene, when it forms its daughter gene, copies its new structure rather than reproducing the old type. It is only because it can do this that the mutant gene can become permanently incorporated in the species.

We must infer that each one of our thousands of present-day genes represents the product of a long succession of advantageous mutations (the far more numerous disadvantageous ones having died out). These advantageous, selected mutations have gradually differentiated each gene and caused it to become ever more specialized and more nicely adapted to playing its present role or roles, whatever they may be, in the system of operations occurring in the organism. By the selection of the better combinations of those newer mutant genes that at present exist only in scattered individuals in a population, the process can be carried further. But after these combinations have become established as the norm of the population, further genetic progress must involve the occurrence of still further mutations, which in their turn must be shuffled in the sexual process and subjected to selection.

Before considering further the processes of accumulation and elimination of mutant genes in populations, let us review some facts regarding the relations of the genes to the characteristics of the organism. Whatever may be the nature of the primary chemical products of the genes within the cell, these products must be of thousands of kinds, corresponding with the thousands of different genes, and these products must interact with one another in innumerable ways to form secondary products, tertiary products, and those ever further removed

from the genes. It is usually only after a very intricate web of these interactions has been carried through that those end-products are at last found which we become aware of as the characteristics of the organism. For only certain features, mostly of a superficial kind, are open to the view of us shortsighted spectators.

Because of the great indirectness of the route connecting the genes with the end-results that we see, it is evident that any given characteristic must be a resultant of the action of many genes, some playing a major role in its development but many more playing only a minor role. Moreover, since some of the reactions constituting the web that leads from gene to character are likely to be more or less responsive to the influence of given environmental conditions, the degree and kind of development of each trait will depend to some extent on these extragenic influences also. It follows that the rules of simple Mendelian inheritance, giving for example a clear-cut 3-to-1 or 1-to-1 ratio among offspring, will operate only in the relatively rare cases in which the observed individuals differ in regard to just one pair of genes that has a major influence on the character studied, and in which the environmental effects also are minor in comparison with those of this gene pair. Thus a gene should not be regarded as the absolute determiner of a trait, but only as a conditional determiner, one that gives rise to the possibility of a given biological effect being produced, provided that other conditions, genetic and environmental, are appropriate. The degree of this conditionality itself varies according to both the gene and these conditions. In another sense too, a given gene is not the simple determiner of a given trait, inasmuch as the reactions it initiates, by participating in the biochemical web of processes previously referred to, usually produce multiple effects as a result of the branching of the web. Nevertheless, there is often just one major conspicuous effect, a more characteristic symptom, by which, in practice, we identify a given gene's presence.

The prevalent type with regard to any given trait, that which we call the normal, represents the present-day end-point of a very protracted evolutionary sequence and therefore exhibits that degree of development of the characteristic which in most cases has for a very long time been optimal, even though under present-day conditions it may no longer be optimal. It has accordingly been to the advantage of the species to incorporate within its genetic composition those genes, originally mutant, which aided in the development of the trait that we call normal and which tended to insure its development to approximately its present degree even in the face of fluctuating conditions and variations in minor genes. It is true that the possibility of considerable latitude in development and in physiological reactions also becomes included in the genetic organization, allowing adaptive responses to certain standard variations in the environment, but we do not here refer to this type of influence on the organism. In consequence, now, of the stabilizing arrangements set up by the prolonged selection for "normality," we find that a trait usually tends to develop to nearly its normal degree even in an individual who has received from just one of his parents a mutant gene that would have produced a marked deviation if it had been received from both parents. In other words, in the genetically half-normal, half-mutant individual, whom we call a *heterozygote,* the normal gene tends to be *dominant* and its mutant allele to be *recessive,* so that the heterozygous individual usually appears to be much more like the "pure" or homozygous normal type than like the homozygous mutant (the type which receives the mutant gene from both his parents). Nevertheless, even where dominance of the normal at first sight seems complete, searching investigation usually reveals some influence of the mutant gene in the heterozygous individual. That is, the mutant gene does have at least a small degree of dominance in most cases, and in the case of a minority of mutant genes the dominance of the mutant is considerable and conspicuous.

Now, despite the fact that every species has been subjected to so long a process of selection for stabilization of its traits at the so-called "normal" level, it is notorious that most populations display a large amount of variability in practically every respect. That considerable portion of this variation which is genetic is of course the result of the continued occurrence of mutations. However, not everyone who is a genetic variant from the norm in a given respect, or from his parents' average, represents a newly arisen mutation—in fact, this is very far from the case. Most of the observable variations represent the diverse products of recombination of a great multitude of mutations, the great majority of them minor in their individual effects. All but a few of these mutations arose in remote ancestors and have been handed down ever since, with perpetual shuffling of their combinations.

Our Load of Harmful Genes

It is possible to make some calculations regarding the number of mutant genes present in a population. As we have seen, the great majority of the mutant genes that arise are detrimental. Now each

detrimental mutant gene has only a limited persistence in the population—that is, a limited number of generations during which it will, on the average, be handed down. For at long last its detrimental effect will cause some individual containing it to die before reproducing, or to fail to reproduce, in consequence of the disability caused by that gene. Of course there will also be many cases in which an individual dies off for some reason that has nothing to do with the gene in question, but to balance these there will be in any stable population as many cases of the accidental multiplication of such individuals to a greater extent than the average. Thus the average number of generations through which a mutant gene is transmitted depends on its own "merits." For instance, if it is disadvantageous enough to give its possessors one chance in 20, or 5 percent, of dying out, then it will on the average manage to persist through 20 generations—the reciprocal of its 1/20 disadvantage—before it brings extinction to its line. For it is clear that, on the average, a 1/20 chance of death must require 20 repetitions before it hits the mark, somewhat as in "Russian roulette." If, now, a group of mutant genes conferring a 1/20 disadvantage should arise anew by mutation in each generation with a frequency of, say, one among every 100 individuals, it will follow that in any one generation approximately 20 times 1 percent, that is, 20 percent of the population, will contain these genes. For the population will contain the total number that can accumulate for the 20 generations of their persistence. In other words, the frequency of any genes must be equal to their frequency of origination by mutation in one generation multiplied by the number of generations that they persist.

The curious fact emerges from such calculations that a type of mutant gene that harms its possessor only a little does an amount of damage to the population comparable with that done by a gene having a drastically injurious effect. For one thing, each slightly harmful gene, on the average, causes the extinction of its line by finally bringing about the misfortune of premature death or failure to reproduce, if only by acting as the deciding factor at some critical time. Secondly, even though it produces only a slight handicap, the number of individuals whom it affects—that is, its persistence—is the reciprocal of the amount of damage, so that the total damage it does is about as great as for the very harmful gene. Finally, this damaging effect of the so-called small mutations actually applies to every individual in the population. For, as we shall see, the small mutations attain such a high frequency, by accumulation, that every individual carries some of them and is somewhat reduced in "fitness" by them. Because of the reciprocal relation between accumulation and degree of damage already mentioned, the amount of this effect exerted on an individual by a group of genes of a given mutation frequency will on the average be proportional to that mutation frequency, regardless of the amount of damage done by the separate mutations. That is, genes of more frequent origin will do proportionately more damage, no matter how little or how much charm any one such gene does to one individual. Of course this principle applies to mental just as well as to other features.

We are on much less certain ground when we turn from these principles to a quantitative estimation of the frequency with which mutations arise in man, the amount of their accumulation, and the degree of reduction of fitness of the individual or population that they occasion. However, there are a number of ways of obtaining evidence regarding these matters, and it happens that they all point toward approximately the same conclusions. One way of estimating the total frequency with which mutations arise per generation is to take the average figure for mutation frequency of an individual gene and then multiply it by the probable number of genes. There are several large sources of error in connection with both these figures, but according to a provisional estimate which I have made in this way, at least one person in every five, on the average, and possibly two, three, or even four in five, are carriers of detrimental mutant genes that their parents did not have—that is, there is this frequency of genes representing newly arisen mutations.

This, even at the lowest value that I regard as probable, is a startling figure. For it must be borne in mind that, in effect, every mutant gene that arises must finally be eliminated by extinction of an individual carrying it, and that therefore, over a long course of generations, there must be as many extinctions per generation as newly arisen mutations if the population is not to deteriorate by accumulating ever more of them. Of course some individuals, having a considerable excess of mutant genes over the average number in the population, can in dying account for the elimination of two or more of these genes at once, but on the whole the number of individuals dying out genetically must be of the same order of magnitude as the number of new mutations. It is unlikely that the frequency of dying out is as great as this at present, however. For fewer than one-fifth of persons now born in our country fail to grow up and reproduce, and many of those who do fail represent misfortunes of environment rather than of heredity. Thus it

seems likely that under modern civilization mutant genes are arising in our population a good deal faster than they are being eliminated—that is, they are accumulating.

Through how many generations does the crop of mutations of each generation ordinarily tend to persist and thus to form an accumulated load of mutations carried by each individual? Light on this question is thrown by the findings that show that even seemingly recessive mutations usually have some small amount of dominance, at least. For this dominance, by allowing the mutant gene to harm even the heterozygous individual to some extent, results in a much lower persistence than it would if the gene, before it could do any harm, had to wait for many generations until by mischance it met one like itself at fertilization and thus became homozygous. Even with its slight dominance, however, it is probable that the average detrimental mutant gene persists for several scores of generations, although this is seldom enough to allow it to become homozygous. By multiplying this persistence estimate of several scores of generations by our rather inexact estimate of the frequency of new mutations, we see that all of us must be carrying something of the order of a dozen to several dozen of these detrimental genes. All taken together, they must lower our fitness considerably.

Evidence concerning this problem is obtained from another angle by examination of the results of inbreeding, as in first-cousin marriages, for this practice gives a calculable chance of formation of individuals homozygous for any detrimental genes that are present, and there is a consequent measurable increase in the frequency of premature deaths as well as of other expressions of lowered fitness. The results of such studies are in harmony with those of the preceding line of investigation. They indicate that everyone carries a collection of detrimental genes so large that only a fourth, or even fewer, of these genes would have been sufficient to kill or sterilize him, under the given conditions of living, if these genes had been in homozygous instead of heterozygous condition (*4*). If we estimate their amount of dominance as averaging about 5 percent, this would result in a lowering of the expectation of life and reproduction of the average heterozygous individual by about 20 percent, as compared with an "ideal" man not harboring any such mutant genes heterozygously.

Salutary Diversity

The definitely detrimental genes that we have been considering are by no means the only basis of the genetic variation existing in a population. The great majority of measurable traits have a certain range of variation within which a difference in a given direction has little if any consistent or overall influence on the individual's chances of survival or reproduction, in that a given difference, such as for instance a somewhat greater height, may according to variable circumstances and accompanying genes be as likely to be advantageous as disadvantageous. Thus, although a given difference is hardly ever effectively neutral in selective value when the rest of the genes are held constant, nevertheless, the different alleles of different genes are likely to have become balanced at a series of frequencies such as to result in the average value of the trait being as near as possible to the optimum in relation to any long-standing conditions of living.

In addition, the range of variation is sometimes kept wide by an active process of natural selection. This happens in cases in which a given minority type finds itself at a premium when its numbers are below a certain level but is at a disadvantage when its members are numerous. This sort of thing has a geographic basis if a portion of the territory of a fairly stationary population presents special environmental conditions, favoring the type in question, that are not found in the territory at large. It has a more purely ecological basis where, within the same territory, there are advantages to the species in having diverse capabilities and attributes, specialized for different modes of life, but the result will not follow unless mechanisms exist for allocating the individuals into those ecological niches for which they are better adapted. Such mechanisms often occur among animals of comparatively high intelligence, especially human beings. It has long been a pet contention of mine, for example, and it is one that has been independently espoused by the distinguished ophthalmologist, Riddell, of Glasgow, that myopia, although certainly a detrimental condition for most individuals, was advantageous in primitive communities for those possessing it so long as they remained a small minority, by giving them the relatively privileged, safer jobs of doing precision work such as shaping fine arrow points. This illustrates the way in which a certain amount of diversity may be actually fostered. It seems quite possible that some genetic characteristics that would be associated with leadership belong in a similar category. But where there is no tendency for sorting the individuals with the distinctive traits out into their respective roles, the selection favoring diversity fails to work.

Still another process for maintaining diversity goes into operation in cases in which there is for any reason a premium on the heterozygous type in

contrast to both opposite homozygotes. The most cited example of this principle nowadays happens to be the gene for sickle-cell anemia prevalent in parts of Africa. The milder change in erythrocytes occurring in heterozygotes has given evidence of rendering its possessors less suitable as hosts for the virulent type of malaria present there, and it frequently saves their lives in this way, yet the mutant gene cannot multiply enough to crowd out the normal gene since when it becomes homozygous its own effects in causing a drastic anemia are fatal. Thus diversity for this characteristic is maintained in this region, but only at the cost of the continual dying out of the numerous homozygotes.

Although there is evidence of the long-continued action of the same mechanism, based on the superiority of the heterozygote, in the case of a number of genes determining antigenic differences, such as those of the blood groups, and the same thing may hold in the case of various other traits, the principle is, fortunately, far from a general one. For if the heterozygous type were in general the superior one, the maintenance of each superior type would be possible only at the expense of the continual throwing off of inferiors, and those inferiors would form a more numerous incubus, the greater the relative success of the heterozygotes. The more generally applicable rule is that which I have mentioned earlier—that the heterozygote tends to stand part way in its characteristics and also in the degree of disadvantage or advantage it confers, between the two opposite homozygous types. The exceptional cases of the heterozygote being superior are probably represented for the most part (leaving out a few blood-group genes) by adaptations that have not yet stood the test of geologic time. For we should expect natural selection in the end to find mutations giving gene combinations which can achieve in homozygous form the same beneficial effects that at first could be attained only by the unstable, wasteful means provided by the selection of heterozygotes.

The phenomenon called heterosis or hybrid vigor is often confused with the one discussed in the two preceding paragraphs, but genetic analysis has given little ground for such identification. The general debilitations, often accompanied by particular disabilities and defects, that is usually found when organisms which ordinarily intercross are inbred, is caused by the bringing together of like recessive mutant genes of detrimental nature. These genes, of course, have far less influence in the heterozygous parents than in their homozygous offspring, but it is probable that in the great majority of cases the individual homozygous for the normal allele would be superior even to the heterozygote. In small communities, especially where selection has been lax, there has been a more or less accidental accumulation of such genes. That is, the diversity of the types of mutant genes present has decreased through the smallness of the numbers, and those types that remain are correspondingly more frequent and more likely to be homozygous, even though the inbreeding may not have been very close. In contrast to this, when the individuals of the two such communities, which differ in regard to the recessives that have become prevalent, breed with one another, their offspring, being homozygous for fewer of the mutant genes (although heterozygous for more of them), approximate more nearly the ideal "normal" condition.

This example touches upon another important principle of population genetics: the phenomenon of drift, as Wright has called it, whereby given mutant genes happen to become established in a certain group of individuals without presenting any advantage at all, just as a result of a succession of accidents of multiplication. This process depends purely on the statistical fluctuations to which small numbers are subject and cannot occur to any considerable extent in populations that remain continuously large and thoroughly interbreeding, as our modern populations are tending to be. However, populations that are at times reduced to small numbers, like many of those of the past, are subject to the relatively large variations of these small numbers. Thus a large population derived from a few individuals will tend to exhibit the accidental peculiarities of those individuals. More important than pure drift, however, is the divergence which occurs as the result of the diverse selection acting upon different small groups, for some of these groups are likely later to increase in numbers, retaining these divergences.

In fact, selection in exactly the same direction, acting upon separated small groups living under sensibly the same circumstances, may often achieve very different genetic results, even though these effects may in some cases be outwardly the same. For selection can operate only to eliminate or to multiply those mutant genes that have happened, accidentally, to arise, and to become numerous enough to afford a basis for selection. Since a mutation of any given type, in some particular gene, is an exceedingly rare event, of the order of one in 100,000 or one in 1 million, and since most mutant genes that start as detrimentals fail even as a result of accumulation to attain a frequency of more than one in 1000, it is obvious that two different small groups, isolated from one another, will usually offer different materials to the selective mechanism. Thus larger populations that may later be derived

from them will differ in these respects, and the longer the isolation goes on the further will the inner divergence go, especially since the establishment of one unlikeness tends to favor the selection of another one.

There is evidence, however, that human groups have had enough mobility in terms of geologic time and have engaged in so much mixing, in consequence, as to prevent the indefinitely great accumulation of such differences. For a study of the frequencies of antigenic characteristics to be found in the blood shows clearly the gradual change in these frequencies as one passes across the great continental areas. Yet despite these imperceptible gradients, certain more conspicuous characteristics, such as stature, coloration, shape of eye, and others, that we associate with recognized races and subraces, change in a sharper and more extreme fashion. It seems likely that these more conspicuous differences have been maintained by a diversity of selection (including sexual selection, which may in part have been influenced by long-standing traditional attitudes) operating in the different areas, even while the general collection of human genes became to a large extent pooled. Today, however, these geographically diverse selective forces are weakening as our artificial devices, such as sunglasses, vitamin capsules, modern garments, heating and cooling, and so on, are obviating the need for these special biological differentiations. At the same time, it is evident from the results of race crossing that few or no drastic incompatibilities have yet come to exist between the diverse gene systems that have arisen in different regions. The worst such incompatibility that we know of, that in the Rh system, exists *within* the European peoples themselves, and can only be improved—for them but not for those with whom they cross—by their outcrossing.

Our discussion of nondetrimental diversities has been concerned mainly with that category of genes, arising relatively rarely by mutation, which are not prone to be definitely detrimental, or which at least can find some use under certain existing conditions. Even though these genes are so infrequent in their origination, they become very frequent by accumulation just because they have such a low rate of elimination. It is probably these genes rather than the much more frequently arising, definitely detrimental genes which, on the occurrence of some change of conditions favoring a different type, usually furnish the material for the next step in evolution.

It is important for the medical man, the educator, the legislator, and all who have to do with the policies shaping the treatment of human beings and the sorts of lives they lead, to be realistic in recognizing the existence of great genetic diversities, both those in the normal range and those caused by the more detrimental genes or by unusual accumulations of the lesser ones. Only by facing these differences, studying them, and diagnosing them, can the course of education, the modes of character training, the kinds of jobs and of living arrangements, and the medical treatments, be properly suited to fit these diversities and to give to each person the opportunity to make the most of his own nature. Mass methods have been only a first step. We all do have an enormous amount in common, but instead of trying to iron out our differences we ought to try to take advantage of them and to cultivate in beneficial ways their diverse potentialities. Harmony is not uniformity.

Improvement for the Worse?

It would take us too far afield here to analyze the radical changes which modern civilization has brought in the conditions of selection. Surely the diverse selection occurring in small isolated groups is rapidly on the way out, and even the differences in selective factors between the larger groups are fading. In fact, the whole basis of selection that in the long past has served to bring us to our present estate seems under modern conditions to be in process of disintegration. This fact can be best appreciated if in closing we return to a consideration of our huge load of detrimental mutations.

The existence of this load should not in itself be a cause of alarm, for it dates back more than a billion years. We know that life in this world is necessarily full of imperfections and that it has nevertheless advanced just because new things were tried, of which the majority failed but the small minority succeeded in a relative sense. The ground for concern lies in nearly the opposite direction—in the fact that our scientific and social advances, our artificial aids to living, our therapies and our prophylaxes, are enabling us to counteract to a considerable extent the harmful effects of many mutant genes and thus to retard their elimination and foster their accumulation, while at the same time some of our physical practices, such as the increasing use of radiation, are causing an accelerated production of mutations.

The obvious defense for our ameliorative procedures is that we can afford the resultant increase in our load of mutations since we have lessened the damage done by the individual mutations. Unfortunately this argument overlooks the fact, previously discussed, that in the long run mutations having only a small harmful effect do about as

much damage to a population as an equal number of highly injurious mutations, because the small deviations accumulate so much as to give rise, in the end, to just as heavy a load of disability as the large ones. This means that our modern methods are causing the load of mutations slowly to rise, and that this rise must continue until, even with all present and future aids to living in active operation and consuming a maximal proportion of our efforts, we will again be having as many failures in life resulting from genetic inadequacies that can no longer be held at bay, as had plagued mankind in his old prescientific days. In other words, the mere maintenance of the level of infelicity characteristic of primitive man would then be possible only by the full use of all our artifices. This procedure would constitute a social burden even more onerous than the rigors of primitive life.

All this illustrates the principle that the prevailing harmfulness of mutations results in a downward pressure toward deterioration that only selection finally counteracts. When, as in some parasites, any organ or trait can be dispensed with and is no longer actively maintained by natural selection—that is, by the dying out of the mutants with that organ weaker—then the organ gradually subsides and is lost. It is possible to circumvent this principle only by substituting artificial selection for natural selection. In the human species this would mean the institution of social and economic conditions, mores, motivations, and an educated understanding, of such a nature as to lead men and women to regard reproduction as essentially a social service, constituting one of their most important contributions to society, and to lead them at the same time to accept a realistic appraisal of genetic values, including those applying to themselves.

Such a revolution in outlook and in resultant practices, which I believe will eventually come about with a spread of education in these matters, would not only tend to prevent genetic deterioration but even to promote genetic improvement. In such a situation, all advances made in therapy, hygiene and, in general, in the "art of living," could only redound to the increase of human well-being. For they would no longer carry in their train the enervating aftermath of a compensatory increase in the mutational load. If we do not hitch our wagon of humanity to this star of controlled reproduction, it will inexorably although perhaps imperceptibly roll down hill, despite all our efforts in the opposite direction, or rather, as an indirect consequence of those very efforts at improvement.

References and Notes

1. Zoology Department contribution No. 614. Time for preparing this report was made available in part by U.S. Atomic Energy Commission contract AT-(11-1)-195.
2. B. Price. "Primary biases in twin studies: a review of prenatal and natal difference-producing factors in monozygotic pairs," *Am. J. Human Genetics* **2**, 293 (1950).
3. J. V. Neel and W. J. Schull, *Human Heredity* (University of Chicago Press, Chicago, Ill., 1954), pp. 277-281.
4. N. E. Morton, J. F. Crow, H. J. Muller, "An estimate of the mutational load in man from data on consanguineous marriages," *Proc. Natl. Acad. Sci. U.S.* 42 (Oct. 1956).

It is with deep regret that we announce the death of Mark H. Adams, a member of the Editorial Board of *Science* and *The Scientific Monthly*. His uncompromising integrity, high standards, penetrating judgment, and sharp discrimination led us to depend on him for advice about many difficult editorial decisions. His death is a serious loss to science and a deep personal loss to us.—EDITORIAL BOARD.

Some Peaceful Uses of Atomic Energy

W. KENNETH DAVIS, SHIELDS WARREN, WALKER L. CISLER

Mr. Davis is director of the Division of Reactor Development of the U.S. Atomic Energy Commission. He was formerly professor of engineering at the University of California and was manager of research of the California Research and Development Company. Dr. Warren served as director of the Division of Biology and Medicine of the AEC from 1947 to 1952. A distinguished authority on cancer research, he is now director of the Cancer Research Institute of the New England Deaconess Hospital, Boston, Mass. Mr. Cisler, an engineer by profession, is extensively and intensively qualified in the public utilities field. He is president of the Detroit Edison Company and of the Fund for Peaceful Atomic Development. This article is based on presentations made to the joint symposium of the National Academy of Economics and Political Science, the Oak Ridge Institute of Nuclear Studies, Section K of the AAAS, and the National Social Science Honor Society Pi Gamma Mu at the Atlanta meeting of the AAAS, 26–31 Dec. 1955. It was edited by Donald P. Ray, executive secretary, National Academy of Economics and Political Science, and secretary, Section K, AAAS.

Industrial Applications of Atomic Power

ATOMIC energy is emerging as a new source of power potentialities (*1*). The reserves of nuclear fuels—uranium and thorium—are plentiful and, in terms of energy content, relatively inexpensive. Furthermore, because of the high energy concentration of nuclear fuels, the cost of transportation is almost negligible compared with that of equivalent quantities of fossil fuels.

The heat resulting from the fission process can be put to many uses. It can be utilized either directly or indirectly through heat exchangers to form steam, which can then be used in the conventional manner as the working fluid in a turbine or for space heating. The turbine, of course, can be connected to an electric generator or can be used as a source of mechanical power. Power reactors may vary in size from the heat source for large central-station generating plants to the source for small, portable units for remote locations.

Process-heating applications also appear to have promise. The heat transfer could take place either in or outside the reactor by means of a coolant circulated through the reactor. The gasification of solid fuels has attracted considerable interest. Liquid and gaseous fuels can be produced from coal, but about 50 percent of the heat content of the coal must be used for supplying the heat necessary for conversion. Unfortunately, the gasification process requires temperatures on the order of 2000° to 2500°F, and we do not yet know how to build a nuclear reactor that will operate at these temperatures.

Reactor products other than heat are also important. One of the most important is the new fissionable material that can be produced by neutron capture. The thorium and most of the uranium occurring in nature are not fissionable except with neutrons of exceptionally high energy. However, by irradiation with neutrons in a reactor, these materials can be transmuted into fissionable isotopes suitable as reactor fuel. In this manner, it is possible to utilize fully the large reserves of thorium and uranium. The fissionable material so formed can be isolated chemically and reused—in the same reactor or in a different one.

The fission process results in the formation of a large number of intensely radioactive elements that may be used as sources of high-energy gamma rays for such applications as food sterilization, catalysis of chemical reactions, and enhancement of desirable physical properties of plastics. Since similar radiations are also present in an operating reactor, it is possible that large-scale applications could be carried out in a suitably designed reactor, even one built principally for production of heat and electricity. In addition, by irradiating readily available elements in a reactor, valuable radioactive isotopes can be formed. Radioisotopes have found widespread use in medical research and therapy, agricultural research, and industrial operations.

Propulsion and power reactors. All these applications are being studied by the U.S. Atomic Energy Commission. Much of the effort has been directed toward development of reactors for propulsion and power generation. The inherent characteristics of reactors, including high heat content per unit

weight of fuel, production of heat without need of oxygen, and infrequent refueling, make them peculiarly suitable for military applications such as ship and aircraft propulsion and as sources of power for remote bases. About 70 percent of the commission's reactor development work is concerned with these applications. However, the effort devoted to industrial uses of reactors has become increasingly important. The objective of the Government is to provide the technological basis upon which full-scale applications can be made by industry. Reactors for electric power generation appear to be one application most promising for relatively early and widespread use, and their development comprises the major part of the AEC's civilian reactor program.

The power reactor activities consist of the development of basic technology, the testing of concepts by reactor experiments, and cooperation with industry on projects for full-scale prototype nuclear power plants. General engineering development in shielding, reactor control methods, chemical processing, waste disposal, metallurgy and materials, heat transfer, and fluid mechanics is also carried on. In addition, studies are conducted of reactor hazards and methods for minimizing them and of standards for protection against radiation.

The power reactor experiments, which involve the construction and operation of small experimental reactors, serve as the "pilot plant" stage of industrial development practice. Table 1 summarizes the experimental program of the Federal Government.

Homogeneous Reactor Experiment No. 1. One reactor experiment has been entirely completed, and the reactor has been dismantled; two others are still in operation. The one that has been completed is Homogeneous Reactor Experiment No. 1 (HRE No. 1), an embodiment of a concept proposed by Oak Ridge National Laboratory. The fuel is a dilute solution of uranyl sulfate in ordinary water which also serves as moderator and heat-transfer medium. The solution is pumped through the reactor core, where it is heated by fission, through an external heat exchanger in which steam is formed, and back to the reactor.

This arrangement has important potential advantages. The core design is mechanically simple. The reactor is very stable from the standpoint of nuclear safety. There are no fuel element problems, for there are no fuel elements. The fission products formed are, of course, carried in the solution; hence, the chemical processing to remove them is greatly simplified, for the difficult and expensive process of dissolving fuel elements is not necessary. The costly refabrication of the fuel elements is also avoided. This possibility of continuous removal of fission products, many of which are neutron absorbers, makes the reactor attractive as a breeder operating on the thorium-uranium-233 cycle.

The problem of fuel-element stability, however, has been traded for the problem of containing the highly radioactive and highly corrosive solution in a complex "plumbing" system. The maximum reactor temperature and pressure are limited by materials, corrosion, and mechanical design so that steam conditions appear to be restricted to lower temperature and pressure than are customary in modern steam practice.

HRE No. 1 operated for about 2 years and demonstrated the basic technical feasibility of the concept. It was then dismantled to make room for the fabrication of a second reactor—HRE No. 2. HRE No. 2 uses for fuel a dilute solution of uranyl sulfate in heavy water. The uranium used is highly enriched in uranium-235.

Experimental Breeder Reactor No. 1. An entirely different type of reactor has also been operated successfully, Experimental Breeder Reactor No. 1 (EBR No. 1), developed by Argonne National Laboratory. This reactor is located at the National Reactor Testing Station in Idaho and is in continuous operation.

While most of the reactors under serious consideration are thermal reactors with neutron energies of a few hundredths of an electron volt, EBR No. 1 operates in a "fast" neutron spectrum—that is, with energies of the order of several hundred thousand electron volts. The most important advantage of fast reactors is that the conversion of the nonfissionable uranium-238, of which 99.3 percent of the world's uranium is constituted, into fissionable plutonium can be made more efficient than in thermal reactors. With proper design, it is possible to produce more new plutonium than the amount of fuel destroyed in the process.

Because little moderation of neutrons can be tolerated, materials used in this reactor must be limited in volume and must be of high atomic weight. The core is necessarily small in comparison with that of thermal reactors. The extremely high heat release per unit of volume imposes severe heat-transfer problems. Water, attractive as a coolant from the heat-transfer aspect, cannot be used because of its moderating characteristics. The best coolant seems to be sodium, or a sodium-potassium mixture, which also has good heat-transfer properties. The large inventory of fissionable material required, however, makes for high capital costs and high fixed charges.

Preliminary design of EBR No. 2 has been completed at Argonne National Laboratory, and the

Table 1. Plants financed wholly or principally by the Government.

Item	Experimental Breeder Reactor No. 1	Experimental Breeder Reactor No. 2	Homogeneous Reactor Experiment No. 1	Homogeneous Reactor Experiment No. 2	Boiling Reactor Experiment No. 3
Location	NRTS, Idaho	NRTS, Idaho	Oak Ridge	Oak Ridge	NRTS, Idaho
Type of reactor	Fast breeder	Fast breeder	Homogeneous	Homogeneous	Boiling water
Heat output	1400 kw	62,500 kw	1000 kw	5220 kw	15,000 kw
Gross elec. capacity	200 kw	20,000 kw	140 kw	300 kw	2400 kw
Responsible lab. or contractor	Argonne	Argonne	Oak Ridge	Oak Ridge	Argonne
Control method	Movable blanket and U^{238} rods	Movable blanket and fuel rods	U concn. and temp. coeff.	U concn. and chem. soln.	Control rods
Decision to proceed	Nov. 1947	Feb. 1954	Apr. 1950	Feb. 1954	Mar. 1955
Design start	Jan. 1948	Aug. 1956	July 1950	Feb. 1954	Mar. 1955
Construction start	Oct. 1949	July 1957	Sept. 1950	July 1954	Mar. 1955
Period of completion and start-up operation	Aug. 1951–Dec. 1951	Apr. 1959–Oct. 1959	Apr. 1952–Feb. 1953	Apr. 1956–Nov. 1956	June 1955–July 1955
Steam conditions	400 lb/in.² gage, 525°F	1250 lb/in.² gage, 850°F	200 lb/in.² abs., 382°F satd.	520 lb/in.² abs., 471°F satd.	285 lb/in² gage, 415°F satd.
Reactor outlet temp.	600°F	900°F	482°F	572°F	419°F
Reactor pressure	15 lb/in.² gage	50 lb/in.² gage	1000 lb/in.² gage	2000 lb/in.² gage	300 lb/in.² gage
Moderator	None	None	H_2O	D_2O	H_2O
Coolant	Na K	Na	Circulating fuel soln.	Circulating fuel soln.	H_2O
Amt. of fuel per loading	52 kg	350 kg	2 kg	5.2 kg	13.8 kg
Enrichment in U^{235}	About 90%	60%	About 90%	About 90%	About 90%

Item	Experimental Boiling Water Reactor	Sodium Reactor Experiment	Los Alamos Power Reactor No. 1	Los Alamos Power Reactor No. 2
Location	Argonne	Santa Susana, Calif.	Los Alamos	Los Alamos
Type of reactor	Boiling water	Sodium graphite	Homogeneous	Homogeneous
Heat output	20,000 kw	21,000 kw	2000 kw	1000 kw
Gross elec. capacity	5000 kw	6000 kw	None	None
Responsible lab. or contractor	Argonne	Atomics International	Los Alamos	Los Alamos
Control method	Control rods	Control rods	Vol. of soln., temp. coeff., control rods	Vol. of soln., temp. coeff.,movable reflector
Decision to proceed	Dec. 1953	Feb. 1954	Feb. 1954	July 1954
Design start	Sept. 1954	Jan. 1955	May 1954	Oct. 1954
Construction start	May 1955	Apr. 1955	Sept. 1954	Feb. 1955
Period of completion and start-up operation	Oct. 1956–Feb. 1957	Oct. 1956–Mar. 1957	Dec. 1955–Aug. 1956	May 1956–Nov. 1956
Steam conditions	560 lb/in.² gage, 479°F satd.	600 lb/in.² gage, 825°F	3600 lb/in.² abs.	600 lb/in.² abs. satd.
Reactor outlet temp.	488°F	960°F	800°F	600°F
Reactor pressure	600 lb/in.² gage	3 lb/in.² gage	About 3900 lb/in.² gage	About 800 lb/in.² gage
Moderator	H_2O	Graphite	H_2O	H_2O
Coolant	H_2O	Sodium	H_2O	H_2O
Amt. of fuel per loading	4566 kg	2570 kg	4.25 kg	3.85 kg
Enrichment in U^{235}	1.4%	2.778%	About 90%	About 90%

Item	Los Alamos Molten Plutonium Reactor Experiment	Organic-Moderated Reactor Experiment	Liquid Metal Fuel Reactor Experiment	Pressurized Water Reactor*
Location	Los Alamos	NRTS, Idaho		Shippingport, Pa.
Type of reactor	Fast breeder	Organic moderated	Liquid metal fuel	Pressurized water
Heat output	About 1000 kw	16,000 kw	5000–10,000 kw	236,000 kw
Gross elec. capacity	None	None	None	60,000–100,000 kw
Responsible lab. or contractor	Los Alamos	Atomics International	Brookhaven	Westinghouse Elec. Corp. and Duquesne Light Co.
Control method	Movable reflector	Controls rods	U concn., temp coeff., control rods	Control rods
Decision to proceed	June 1955	Oct. 1955	Nov. 1955	June 1953
Design start	Jan. 1956	Oct. 1955	Jan. 1957	June 1953
Construction start	Nov. 1956	June 1956	Unknown	Sept. 1954
Period of completion and start-up operation	Nov. 1958–May 1959	Dec. 1956–Mar. 1957	Unknown; Dec. 1959	June 1957–Jan. 1958
Steam conditions	None	None	None	585 lb/in.² gage satd.
Reactor outlet temp.	Not available	710°F	Not available	540°F
Reactor pressure	Not available	300 lb/in.² gage	Not available	2000 lb/in.² gage
Moderator	None	Diphenyl	Graphite	H_2O
Coolant	Na K	Diphenyl	Circulating fuel soln. in bismuth	H_2O
Amt. of fuel per loading	About 15 kg of molten Pu Alloy	20.75 kg	Not available	12 tons of natural U and 52 kg
Enrichment in U^{235}	Not available	About 90%	Not available	About 90%

* The estimated cost of the plant is $47,750,000. Thus the cost per electric kilowatt is between $477 and $795, depending on the electric output.

architectural-engineering phase has begun. The new reactor will be sodium-cooled, will generate 62.5 megawatts of heat, and will produce 20,000 kilowatts of electricity. Consideration is being given to placing EBR-2 at Argonne. It is hoped that the reactor can be in operation in late 1958.

Boiling reactor experiment. The boiling reactor experiment (Borax III) at the National Reactor Testing Station is one of a series of small, temporary reactors designed by the Argonne Laboratory to test the feasibility of boiling water in the core of the reactor and utilizing the steam directly in a turbine. In addition to eliminating an external heat exchanger, this scheme has the advantage that the steam pressure and temperature can be as high as the reactor vessel will stand. Obviously, a cheaper reactor vessel can be used than is required for a pressurized water system which operates at about 2000 pounds per square inch, and higher steam pressure can be produced without excessive cost.

Borax III was shut down in April 1956 after it had operated for about 6 months at rated temperature and at power levels up to about 2000 kilowatts (electricity). A second core of oxide fuel elements is being fabricated and will be used in continuing the experiment as Borax IV. Initial operation is expected early in fiscal year 1957.

An important feature of this type of reactor is that an increase in the amount of steam formation tends to reduce the reactor power level. While this feature contributes to the safety of the reactor, the reactor's automatic response to changes in demand for electric power is an inverse relationship. An increase in demand, for example, leads to lower reactor pressure, increase in the steam volume, and reduction in reactivity and power—not the desired increase in power. External control methods that add to the cost are necessary. Incomplete knowledge of boiling heat transfer phenomena constitutes another problem.

Program for power reactor development. A program consisting chiefly of reactor experiments, sometimes called the 5-year program, was announced by the AEC in March 1954. The four experiments and one full-scale reactor making up the program represented concepts that are eventually expected to be capable of producing economically competitive electricity. Three of these experiments are of the types just described but in larger and more advanced units—Homogeneous Reactor Experiment No. 2 (HRE No. 2), Experimental Breeder Reactor No. 2 (EBR No. 2), and Experimental Boiling Water Reactor (EBWR). The two additional types are the Sodium Reactor Experiment and the full-scale Shippingport Pressurized Water Reactor.

Sodium Reactor Experiment. The Sodium Reactor Experiment is being fabricated by Atomics International, a division of North American Aviation, Inc. This reactor will use liquid sodium as the coolant and graphite as the moderator. The use of sodium makes high temperatures achievable without the accompanying high pressures that are required when water is used. The thermal efficiency increases with increasing temperature. Thus, in a sodium-cooled system, relatively high efficiencies can be achieved without a large increase in construction cost. However, sodium-handling techniques are not yet well developed, and the design is complicated by the necessity of guarding against a sodium-water reaction and of protecting the uranium and graphite from the sodium. Sodium also becomes highly radioactive when it is irradiated; hence extra shielding is necessary.

Shippingport Pressurized Water Reactor. The Shippingport reactor is based on technology that has been developed further than the technology of any of the other reactors. Two reactors of this type have already been operated—those of the Navy's submarine *U.S.S. Nautilus* and its land-based prototype plant. The Shippingport plant, which is being built near Shippingport, Pennsylvania, will be the first large nuclear power generating station in this country, with a capacity of at least 60,000 electric kilowatts. This plant is not expected to produce economical power but rather to provide information that can be obtained only from the construction and operation of a full-scale prototype. The reactor is being built for the AEC by Westinghouse Electric Corporation. The Duquesne Light Company is furnishing the turbogenerator portion of the plant and will operate the entire plant for the AEC. Power generated will be fed to the Duquesne system.

Los Alamos power reactor experiments. The Government's reactor development program is being enlarged. The technology of several other concepts has advanced sufficiently for fabrication of reactor experiments. The Los Alamos Scientific Laboratory has built Los Alamos Power Reactor Experiment No. 1 and is presently completing Los Alamos Power Reactor Experiment No. 2. Both LAPRE No. 1 and LAPRE No. 2 are small aqueous homogeneous reactors, different from the Oak Ridge reactor in that a phosphate solution is used rather than sulfate. Phosphate solutions may be more stable under irradiation. High concentration of uranium is also possible; hence, smaller core sizes. However, the phosphate solutions are more corro-

sive; rather exotic materials, such as gold, are required to contain them. The heat exchanger of each reactor will be inside the pressure vessel, thus reducing the volume of fuel required and making unnecessary its circulation outside the vessel. These two Los Alamos reactors will differ in that one will use forced cooling and the other natural convection. LAPRE No. 1 has a thermal output of 2 megawatts, LAPRE No. 2, 1.3 megawatts.

Organic-Moderated Reactor Experiment. Another promising concept involves the use of an organic liquid for moderating and cooling. The boiling point of compounds found suitable for use is high enough that power-plant temperatures can be achieved without high pressure. For example, temperatures in the range 600° to 700°F are possible at near atmospheric pressure without boiling. In addition, organic compounds are extremely good moderators, and thus the core may be as compact as it is in a water-moderated reactor. Most organic compounds are susceptible to high temperature and radiation damage and usually polymerize into tarry substances that may foul heat-transfer surfaces. However, certain hydrocarbons, such as diphenyl and terphenyl, appear to resist this damage satisfactorily. An Organic-Moderated Reactor Experiment is expected to be completed by about October 1956 with Atomics International as the contractor. A further phase in the development of organic reactors is being undertaken under the naval reactors program. The Knolls Atomic Power Laboratory of the AEC will design a reactor experiment that is expected to provide information on specific engineering problems incident to the use of organic compounds as coolants for naval reactors.

Liquid Metal Fuel Reactor. Technologic advancement of another reactor concept—the Liquid Metal Fuel Reactor—has warranted proceeding with a reactor experiment. Accordingly, the AEC has begun negotiations with the Babcock and Wilcox Company for the development, design, fabrication, and operation of such an experiment. In this concept, the uranium is dissolved in molten bismuth. This fuel solution serves as the heat-transfer medium and will be pumped through the reactor and heat exchanger. Investigations at Brookhaven National Laboratory show that graphite and a low-chrome steel are suitable materials for the core. It is possible to achieve high temperatures—on the order of 1400°F—at atmospheric pressure. Hence, steam conditions for a modern turbogenerator should be obtained. Calculations also show that breeding may be possible with uranium-233 as fuel and thorium as a blanket.

A major disadvantage of this concept is the low solubility of uranium in bismuth, which necessitates the use of highly enriched uranium. In addition, the entire system must be provided with an external heat source for start-up, for bismuth melts at a very high temperature. Components suitable for use have not yet been completely developed, and the behavior under irradiation of the fuel and the containing material in combination is not known. Information on nuclear stability must also be obtained.

Other possible reactor types. High-temperature reactors such as the Liquid Metal Fuel Reactor might be used with a suitable gas as the coolant in a closed-cycle gas turbine system. Such plants would be relatively independent of their environment—that is, no condenser cooling water would be required. Efficiencies that seem realizable are quite high—perhaps 40 percent. Capital costs for small plants—in the range of 5000 to 40,000 kilowatt—might be less than for other types of nuclear plants. The temperatures necessary for efficient operation are about 1200° to 1400°F and, of course, technology for this temperature range has not yet been developed. However, problems and design of gas-cooled systems are being studied.

A promising reactor concept on which work was started recently involves the use of a molten plutonium alloy as the fuel solution and coolant. High temperatures would be possible with this system, and a fast-breeder reactor using such a fuel is potentially feasible. Many problems must be solved, however, before this concept can become a reality. Preliminary work is being done at Los Alamos Scientific Laboratory, where the project is known as the Los Alamos Plutonium Reactor Experiment (LAMPRE); the scheduled operating date is 1959.

Prototype power reactors by industry. The Government program consists of one full-scale nuclear power plant and nine smaller reactor experiments; it is primarily Government financed. Private industry is now undertaking the development and construction of full-scale prototype plants primarily or entirely with its own money. Each of the first five reactor types in the Government's 5-year program is represented by a prototype in the private-industry program. The Government projects will supply much necessary technical data, but the scale-up presents formidable design problems, and the construction and operation of the large plants will provide information that is not obtainable by any other means. Information about the plants that are being financed wholly by private industry is presented in Table 2.

The Commonwealth Edison Company of Chicago, and associates, with the General Electric

Table 2. Plants financed wholly by industry.

Item	Consolidated Edison Co. of N.Y.	Commonwealth Edison Co. and others	Pennsylvania Power and Light Co.	General Electric Co.; Pacific Gas and Electric Co.	Florida Power Corp. and others
Location	Indian Point, N. Y.	Dresden, Ill.	Eastern Pennsylvania	Vallecitos, Calif.	Not available
Type of reactor	Pressurized water	Boiling water	Aqueous homogeneous	Boiling water	Not available
Heat output	500,000 kw	630,000 kw	Not available	12,000 kw	Not available
Gross elec. capacity	250,000 kw*	180,000 kw	150,000 kw	3,000 kw	200,000 kw
Total est. cost	$55,000,000	$45,000,000	Not available	Not available	Not available
Cost per elec. kilowatt	$220	$250	Not available	Not available	Not available
Decision to proceed	Feb. 1955	Apr. 1955	July 1955	Oct. 1955	Not available
Design start	Feb. 1955	Dec. 1955	Jan. 1958	Oct. 1955	Not available
Construction start	Nov. 1956	Sept. 1956	Unknown	May 1956	Not available
Period of completion and start-up operation	Sept. 1959–Oct. 1960	Dec. 1959–Mar. 1961	June 1962–Unknown	June 1957–Feb. 1958	1962
Steam conditions	370 lb/in.^{2} abs; 1000°F satd.	970 lb/in.^{2} abs., 540°F	600 lb/in.^{2} abs.	Not available	Not available
Reactor outlet temp.	510°F	480°F	Not available	Not available	Not available
Reactor pressure	1500 lb/in.^{2} gage	1000 lb/in.^{2} abs.	Not available	Not available	Not available
Moderator	H_2O	H_2O	Not available	H_2O	Not available
Coolant	H_2O	H_2O	Fuel solution	H_2O	Not available
Amount of fuel per loading	10,000 kg U and 8275 kg Th	68,000 kg	Not available	30 kg	Not available
Enrichment in U^{235}	About 90% for U	1.1%	Not available	About 90%	Not available

* Includes 110,000 kw of conventional superheating capacity.

Company as a prime contractor, has proposed the construction of a 180,000-kilowatt plant based on a modification of the Experimental Boiling Water Reactor. The plant is to be located on the Commonwealth Edison system. The Consolidated Edison Company of New York has contracted with the Babcock and Wilcox Company for the design and construction of a combination nuclear-conventional plant with a total capacity of 236,000 electric kilowatts. A conventional superheater will contribute about 96,000 kilowatts of the total. In May, the AEC issued construction permits for these two plants, the first for the private construction of large-scale nuclear power plants. In addition, the Pennsylvania Power and Light Company has announced that a 150,000-kilowatt plant using an aqueous homogeneous reactor is planned with the Westinghouse Electric Corporation as contractor. Further, in March, the General Electric Company and the Pacific Gas and Electric Company reported to the AEC their decision to build and operate an atomic power plant (3000 kilowatts) of the boiling water type to help supply electricity for the San Francisco Bay area.

In addition to the plants that are to be financed wholly by private industry, several others are to be financed principally by private industry (Table 3). Proposals for prototype plants were received by the AEC in April 1955 as part of a Power Demonstration Reactor Program. In June 1956 the AEC signed a contract, the first under this program, with the Yankee Atomic Electric Company. The company, a group of New England utilities, will construct a 134,000-kilowatt pressurized water reactor.

Negotiations are in progress for two other plants. A 75,000-kilowatt sodium-graphite plant is the subject of negotiation with Consumers Public Power District of Nebraska, the proposer. Atomics International is the contractor. The other plant is a 100,000-kilowatt fast breeder reactor proposed by the Power Reactor Development Company, Inc. (Detroit Edison Company and associates).

Government assistance offered to such projects includes meeting a part of the cost of the research and development required, paying for new technical information accruing from the construction and operation of the prototype, and waiving normal AEC lease charges for use of special nuclear materials for several years.

Second power demonstration reactor proposals. In September 1955, the AEC invited proposals for plants in the power ranges between 5000 and 40,000 kilowatts of electricity. Such small and medium-sized plants would satisfy the needs of domestic rural areas with high power costs. Such plants are required also for the majority of foreign applications. Development of nuclear plants that can compete economically with conventional plants in this capacity range is much more difficult than development of large plants. In other cases, industry is taking steps to build full-scale plants in this size range without Government assistance. The seven proposals made in response to the second invitation and received before the closing date of 1 February 1956 are listed in Table 3.

Power reactors by "generations." The length of time between discovery of basic scientific knowledge and large-scale commercial application of that knowledge is ordinarily quite long. Development of reactor technology has proceeded more rapidly than is usually the case. In discussing the length of time involved, it is convenient to talk of "generations"

of reactors. A generation is the time required to complete a new reactor based on the technology demonstrated by a previous one. This time is roughly estimated as follows: component development and testing, 1 to 3 years; engineering design, 1 year; construction, 2 to 3 years; testing and initial operation, ½ to 1 year; significant operation (first core), 1 to 3 years. Taking into account the normal overlap between these phases, a generation appears to be 5 to 7 years.

The first generation of power reactors, represented by the large prototypes now being planned, has not reached the end of the first phase; in some cases component development has not been started. This first generation will certainly not produce electricity competitive with electricity from conventional power plants in the United States. Perhaps the second or third generation will be competitive.

Atomic Energy in Medicine

The impact of atomic energy in medicine is comparable in its effects on that field to its impact and the effects thereof in the political and economic fields (*2*). It has opened new horizons, has made possible new advances, and has posed new problems of health and safety. As for concrete accomplishments in the biomedical field, particularly, what have we to show? Atomic energy has provided, in the form of tagged atoms, a very important re-

Table 3. Plants financed principally by industry. Data shown are based on proposals submitted to the AEC.

Item	Power Reactor Development Co.	Yankee Atomic Electric Co.	Wolverine Electric Cooperative	Rural Cooperative Power Association	Consumers Public Power District
Location	Monroe, Mich.	Rowe, Mass.	Hershey, Mich.	Elk River, Minn.	Beatrice, Neb.
Type of reactor	Fast breeder	Pressurized water	Aqueous homogeneous	Boiling water	Sodium graphite
Heat output	300,000 kw	480,000 kw	31,000 kw*	58,000 kw	245,000 kw
Gross elec. capacity	100,000 kw	134,000 kw	10,000 kw	22,000 kw	75,000 kw
Total est. cost	$45,000,000	$34,500,000	$3,574,000	$6,185,000	$24,300,000
Cost per elec. kilowatt	$450	$260	$357	$281	$324
Decision to proceed	Apr. 1955	Apr. 1955	Feb. 1956	May 1955	Apr. 1955
Design start	Mar. 1956	June 1956	Aug. 1957	July 1956	June 1956
Construction start	Aug. 1956	Apr. 1956	May 1958	July 1957	May 1957
Period of completion and start-up operation	Dec. 1959–June 1960	Dec. 1959–June 1960	June 1959–Oct. 1959	July 1959–Jan. 1960	June 1959–Jan. 1960
Steam conditions	600 lb/in² abs., 730°F	600 lb/in.² abs., satd.	570 lb/in.² gage†, 486°F	600 lb/in.² gage, 825°F	800 lb/in.² gage, 825°F
Reactor outlet temp.	800°F	535°F	570°F	533°F	925°F
Reactor pressure	Atmospheric	2000 lb/in.² gage	1900 lb/in.² gage	900 lb/in.² gage	46 lb/in.² gage
Moderator	None	H_2O	Uranyl sulfate in heavy water	H_2O	Graphite
Coolant	Sodium	H_2O	Circulating fuel	H_2O	Sodium
Amount of fuel per loading	2100 kg	28,800 kg	12 kg	12 kg Enriched; 10,000 kg Normal	22,500 kg
Enrichment in U^{235}	27%	2.5%	Approx. 90%	Fully enriched spikes; Natural U core	2.3%

Item	Chugach Electric Association	University of Florida	City of Orlando	City of Piqua	City of Holyoke
Location	Anchorage, Alaska	Gainesville, Fla.	Orlando, Fla.	Piqua, Ohio	Holyoke, Mass.
Type of reactor	Sodium-cooled, heavy-water moderated	Pressurized water	Liquid metal fuel Th Brd blanket	Organic moderated	Gas-cooled, closed cycle
Heat output	40,000 kw	10,000 kw	Not available	45,500 kw	44,000 kw
Gross elec. capacity	10,000 kw	2000 kw	25,000–40,000 kw	12,500 kw	15,000 kw
Total est. cost	$7,350,000	$1,850,000	$23,600,000	$5,300,000	$6,428,000
Cost per elec. kilowatt	$735	$800	$590–944	$424	$429
Decision to proceed	Apr. 1956	Feb. 1956	Feb. 1956	Feb. 1956	Feb. 1956
Design start	Apr. 1956		Unknown	Unknown	July 1956
Construction start	July 1959		Unknown	Unknown	July 1959
Period of completion and start-up operation	July 1961–July 1962		1961	Unknown, 1960	Nov. 1960–July 1961
Steam conditions	850 lb/in.² gage, 850°F	190 lb/in.² gage, 404°F	1250 lb/in.² gage, 900°F	400 lb/in.² gage, 550°F	488.3 lb/in.² gage, 1300°F
Reactor outlet temp.	950°F	450°F	Not specified	617°F	1292°F
Reactor pressure	Atmospheric	1200 lb/in.² gage	Not specified	50 lb/in.² gage	501 lb/in.² gage
Moderator	Heavy water	H_2O	Graphite	Terphenyl hydrocarbon	Graphite
Coolant	Liquid sodium	H_2O	U^{235} in molten Bismuth soln.	Terphenyl hydrocarbon	Nitrogen gas
Amount of fuel per loading	10,000 kg U	Not specified	60 kg U^{235}, 17,000 lb Th	6000 kg	736 kg
Enrichment in U^{235}	Approx. 2%	Approx. 90%	Approx. 90%	3%	10%

* Includes superheater—7000 kw thermal. † Steam from heat exchanger to gas fired superheater, which delivers steam at a pressure of 515.3 lb/in.² gage at 825°F.

search tool—one that permits the exploration of avenues closed to any other means. The fact that particular atoms and molecules can be identified by Geiger or scintillation counters has made it possible to add time to the known dimensions of biochemical processes in plants, animals, and man, and it has added a degree of specific understanding of biological processes that would be possible in no other way. Just as it has been feasible through the use of carbon-14 to establish clearly the ages of archeological finds of animal and vegetable nature up to some 30,000 years ago, so also has it been possible, with the use of the radioisotopes, to establish to within fractions of a second the time of transport of materials within the body or the time required for chemical reactions within the body.

The radioactive, tagged atoms provide a means by which the utilization of foodstuffs, water, gases, and the various components of the body can be followed through the complex processes of intermediary metabolism, providing concepts of patterns of reaction and speed that could not be achieved in any other way. Not only are the isotopes useful tools in the laboratory, but so also are they useful in the field. Whether one is concerned with the flight of insects, efficacy of fungicides, utilization of fertilizers, photosynthesis, or such specific points as the useful life of the transfused red blood cell, radioisotopes come into play.

In the past, there have been many limitations to careful study of several of these problems. The level of calcium in human blood, for example, is extraordinarily constant, and there was no realization that this constancy was maintained through rapid and delicate chemical shifts. A man's skeleton, furthermore, presents a huge surface—approximately 100 acres if it could be spread out where the bony salts that render it rigid are in contact with the body fluids. Through this huge surface there is a constant interchange of atoms of calcium, of phosphorus, of carbon, of oxygen, and of other elements going back and forth, maintaining a satisfactory and constant level under conditions of health. This could never have been detected were it not possible to identify by tagging each atom so that it can be followed as clearly in its travels through the body as a jet plane at high altitude can be followed by its vapor trail:

It is possible to tag even fairly complex substances. By growing foxgloves in an atmosphere of carbon-14, it is possible to have the digitalis prepared from the plants accurately tagged with radioactive carbon so that the mode of action of the drug can be much better understood than previously. It is feasible to tag hormones with radioactivity and thus follow their complex metabolic paths and be in a better position to utilize that knowledge in medicine. Many chemical processes take place in our bodies so rapidly that ordinary methods of chemical study have given little idea concerning the question of how they are brought about. But with radioisotopes, the steps in the processes can be distinguished clearly and soundly.

From the therapeutic standpoint, advances have been somewhat more limited. Radioactive cobalt provides a cheap and vastly more powerful source of ionizing radiation than radium. It also provides a far more concentrated source of radioactivity than does radium, and its ready availability has permitted its widespread and effective use. It does not promise startlingly different results, however, from those obtainable with the therapeutic use of large external radium sources or supervoltage x-rays. Radioactive cesium is of considerable interest as a source of moderately penetrating therapeutic radiation, but it has not yet been used extensively enough to permit evaluation of the results. Radioactive phosphorus provides the best treatment of polycythemia. It is of palliative value in some other processes, such as leukemia and myeloma.

Radioactive iodine has found wide utilization in the field of thyroid disease, both hyperfunctional and neoplastic. Because of its ease of application and freedom from complications, it has become, perhaps, the most commonly utilized of the radioactive isotopes. It is not recommended for routine use in persons under 45 years of age, however, because of the possible danger of the late development of carcinoma. Radioactive gold has been quite useful in controlling the accumulation of fluid associated with the spread of cancer to body cavities, such as the abdomen or the thoracic cavities. It is not curative, but in a fair number of instances it has provided appreciable palliation. The direct injection of radioactive gold into some tumors has yielded satisfactory results to some degree, but it is not generally utilized in this treatment.

Other therapeutic uses have been and will be found for other isotopes. As yet, very little work has been done with short-lived isotopes because of the difficulty of obtaining and handling them. Nonetheless, this will prove to be a very interesting field for development. A word of caution is necessary, however, that there is no panacea in the radioisotopes—rather they are wonderfully effective tools without which we could not engage in advanced research.

International Cooperation in Atomic Energy

It was exactly 50 years ago that Albert Einstein announced his famous formula upon which is based

the science of today's atomic age (*3*). The formula contains three letters and one digit: $e = mc^2$, e represents energy, m indicates mass, and c equals the speed of light in feet per second. The formula implies that matter may be converted into energy, which we now accept as true, and that the energy in matter—any kind of matter—equals the mass or weight of the material multiplied by the speed of light squared.

If one translates Einstein's formula, it will be found that comparatively few pounds of matter so converted would yield all of the energy now used in the world in 1 year. For practical purposes, we have not yet attained such an accomplishment. We have learned how to fission atoms of certain materials, however, and in so doing, to convert a very small part of those atoms into heat energy. Definite limitations existed formerly on how far electricity could be transmitted. With the facilities developed in recent years, electric power can be moved a mile or hundreds of miles. Atomic fuels are so concentrated, and so easily transported, that we can make heat energy—which can be converted into mechanical and electric energy—available anywhere in the world that it may be utilized.

It costs about $35 to mine and purify a pound of uranium and sell it to the consumer. Through the processes of atomic fission—to the extent that it can already be accomplished—1 pound of uranium metal potentially can yield as much heat, and therefore as much power, as 1300 tons of coal burned in a modern, efficient steam plant. This heat could generate about 3.5 million kilowatt hours of electric power. Theoretically, $35 worth of atomic fuel can yield about the same amount of heat as $10,000 worth of coal. And instead of sending a shipload of coal, a small bar of uranium can be wrapped and sent anywhere in the world, as fast as an airplane can fly. Essentially, for the first time in the world's history, we know how to transport power, or energy, unhampered by the heavy costs of moving it. This fact becomes a matter of international significance.

The question remains of how to put to use in all nations the power known to be available. The problem involves not only the generation of electric power in costly power plants, but also the initiation of methods of utilizing that power. In round figures, an atomic power plant capable of producing 100,000 kilowatts of electricity might be regarded as costing some $25 million. It is known from experience that to put to use that amount of power, an expenditure of from 4 to 15 times as much is necessary—an additional $100 million to nearly $400 million—for the industrial plants, the equipment, the distribution systems, and the machines that utilize power.

The economics of transition of some less-developed areas of the world into the atomic age becomes puzzling indeed when it is realized that it can cost upward of one-third of a billion dollars to establish a 100,000-kilowatt atomic plant and make use of its power. Yet such an economic unit, in terms of conventional power, would be dwarfed by that which has been accomplished within the United States. The Detroit Edison Company alone, for example, furnishes 25 times that much power. And in the entire country, there is installed some 135 million kilowatts of electric generating capacity, including the plants owned by industries for their own use.

Thus, a dream of world-wide plenty through the use of atomic power can be seen, but it is a distant vision. It might be noted that the investment in atomic power throughout the world, as so expectantly envisioned by many, rises to astronomical figures that are comparable only to the amounts of money that mankind spends on war. Can it be supposed that the human race now has come to the age at which it can think of making such investments in the tools of peace instead of the materials of war? The evidence for this position is scant indeed, but we may at least hope for such goals.

American industries are working vigorously to develop atomic power plants which will be available for use throughout the world. The Atomic Energy Commission is supporting this effort, and, together with other Government agencies, is directly assisting the underdeveloped countries through broad research and development programs, by means of reactor demonstration, and by general technical assistance programs.

There has been considerable publicity and criticism concerning the classified or secret aspects of atomic energy. The matter of national security is of extreme importance, and it is necessary to be guided by those in the United States to whom this responsibility has been assigned. Obviously, any security program results in many annoyances. From the practical standpoint, nearly all power-reactor technology has been declassified within recent months, and the security problems have been substantially reduced. The real situation frequently is the unwillingness or inability of those desiring information to peruse adequately the mass of documents to obtain desired information. It should be generally recognized that the AEC cannot be expected to provide specific detailed information.

Further problems with reference to securtiy matters are presented by the fact that some overseas countries have little or no concern for questions of security. This condition, of course, creates incongruous situations at times. The recent declassification actions of the AEC, however, have improved

problems of the case in point. Most of the information about power-reactor technology now held as classified simply is not available outside those countries that have security systems comparable to that of the United States.

Much has been said in recent months to the effect that the United States is falling behind in atomic power development. A careful review will show, however, that the scope of American atomic power development activities exceeds by far the programs of other countries. At the World Power Conference in Vienna, in June 1956, representatives of the United Kingdom stated that the present construction program of that country comprises the 60,000-kilowatt Calder Hall gas-cooled reactor, which is being modified substantially for subsequent installations, and a breeder-type reactor with a capacity of 15,000 kilowatts. Thirteen additional gas-cooled reactors are planned for future construction. Most engineers in the United States and in Europe do not regard gas-cooled reactors highly because of their very large size and poor utilization of uranium fuel. Specialists in the American atomic power industry believe that the fact the Calder Hall reactor is scheduled to operate in the autumn of 1956 is not a matter of vital significance.

Representatives of the U.S.S.R. at the Vienna Conference discussed a 5000-kilowatt reactor revealed to have been operating in 1955. They also told of additional reactors that may be under construction. It was stated that the over-all program of the U.S.S.R. included seven different types of reactors, all of which are included in the programs now under way in the United States. Recent additions to the United States program give its efforts a somewhat greater scope.

The programs in other European countries are generally limited to one or two types of reactors, and certainly there is no evidence of outstanding advancements which equal those that have been achieved in the United States. The real situation with respect to overseas developments seems to be that we in the United States regard our activities as development work and are reluctant to claim success until it can be clearly demonstrated. Overseas spokesmen frequently are inclined to speak of their plans for the future in more optimistic contexts, as successful accomplishments.

While it is believed possible to build workable atomic power plants, there is insufficient experience available now to permit full economic evaluation of such plants, either in the United States or elsewhere. A great deal of thought, study, and developmental work must be done before it is practical to install atomic plants throughout the world. This is particularly true with respect to the local economic conditions. Comparatively unproved atomic plants should not be installed at the present time where conventional plants can provide the necessary power at lower cost.

Although the United States is not the only country working on these intricate problems, it is apparent that it is one of the few nations that now has the resources to develop and to build atomic plants capable of producing electric power and to operate them acceptably. The United Kingdom expects to build 12 such plants in the next 10 years; France is building two such plants. Canada and the U.S.S.R., likewise, have the capabilities to build and operate atomic power plants. The rest of the world is looking for assistance. Belgium, for example, is blessed with a large resource of natural uranium and is aggressively engaged in developmental activity. It has, however, contracted for an American-built plant to be in operation in time to light the World Exposition in Brussels in the spring of 1958. Italy is negotiating in the United States for two atomic power plants. Representatives from the Netherlands have made inquiries, and so have those from Sweden. Groups from nations throughout the world visit the United States frequently to seek aid in atomic projects.

Our sincere desire to give more than lip-service to offers to share our knowledge requires that something concrete be done in these respects. President Eisenhower has taken the leadership in making clear the willingness of this country to share atomic information. He has shown, by a series of pronouncements and actions, his keen recognition of our role in being responsive to the needs of other countries. Two very important steps in these aspects have been taken by the Government. (i) One hundred kilograms of uranium-235 were made available for use by friendly nations in research reactors. About 20 countries have signed bilateral treaties that are expected to lead to the actual use of this material. (ii) The President announced that 20,000 kilograms of uranium fuel will be available to friendly nations for use in power reactors. This will assure, for all practical purposes, that fuel will be available for several years, at least, to all friendly countries that might wish to build power reactors. The expression and leadership of President Eisenhower in these matters is attested to by the approval of the American public. The Department of State and the Atomic Energy Commission are making good progress in carrying out these programs of international cooperation in atomic energy development.

To implement the interest of the United States

toward assistance abroad in the atomic development field, a private group of leaders in industry, labor, commerce, and education joined to form an organization known as the Fund for Peaceful Atomic Development. It was started as a private expression of the desire of many people in this country to demonstrate to others our interest in their self-development in the atomic energy field. Support has come from the Ford Foundation, the Rockefeller Brothers Fund, the Johnson Foundation, and from other groups to its program of research and technical assistance in international atomic energy matters.

The Fund for Peaceful Atomic Development, in line with the Eisenhower concept in this area, seeks to bring about world-wide cooperation on atomic energy problems on a people-to-people, business-to-business, and science-to-science basis. It has already recruited well-known Americans to travel overseas to provide advice and guidance to other countries in their peaceful applications of atomic energy, and it has brought to this country young engineers for training in our universities. Its promotional activities have resulted in the formation of similar private organizations in several countries, including Belgium, Luxembourg, and Italy, and an active expression of interest in the organization of similar groups in Germany, Austria, Japan, Mexico, Canada, and other countries. In this way, the fund is developing nongovernmental relationships among countries so that there can be the fullest and broadest approach to the peaceful development of atomic energy.

Atomic electric power is still in its infancy. Its potential in other countries within the next century is great. The program over the next 10 years needs to be carefully nurtured within the long-term viewpoint. We should be hopeful and confident that our 20th-century industries will recognize the problems. If they do, we can look forward to even greater strides than ever before in cooperation between this country and others.

The world is becoming aware of the immense promise that lies within the nucleus of the atom. Not all understand it. Some, to be sure, have no real understanding of the overwhelming problems that must be met. But American industry, as well as the United States Government, is marshalling its strength in many ways to see that those who turn to this country for help will not be unaided.

Notes

1. The author of this section is W. Kenneth Davis.
2. The author of this section is Shields Warren.
3. The author of this section is Walker L. Cisler.

Gravity Program of the U. S. National Committee for the IGY

GEORGE P. WOOLLARD

Dr. Woollard is professor of geophysics at the University of Wisconsin and an associate scientist in geophysics at the Woods Hole Oceanographic Institution. He has been in charge of a world-wide gravity program under the auspices of the Office of Naval Research and the Cambridge Research Center of the U.S. Air Force. This article is based on a paper presented at the symposium on the International Geophysical Year program for the U.S. National Committee that was held at the Atlanta meeting of the AAAS, 26–31 Dec. 1955.

THE gravity program planned for the International Geophysical Year will be carried out by groups from several nations. Originally the measurements visualized were to be only earth tide studies that would benefit most through simultaneous measurements on a global basis. The program has since been expanded to include pendulum and gravimeter measurements for facilitating studies of the geoid, crustal structure, the origin of island arcs and mountains, and the thickness of the ice and the nature of the subice geology in the polar regions. The United States will be participating in all phases of the program, and the responsibility for a major portion of the over-all program lies with participants from this country.

The groups in the United States that are participating in the gravity program, in the order of their activity, are the University of Wisconsin, the Lamont Geological Observatory of Columbia University, the Woods Hole Oceanographic Institution, the Arctic Institute, and the University of California at Los Angeles.

Gravity Program

The gravity program planned can be subdivided as follows: (i) gravity standardization and control measurements on a global basis for use in studying the geoid; (ii) gravity studies as part of special investigations such as the study of mountain ranges, island arcs, the thickness of ice in the polar regions, and so forth; (iii) exploratory measurements of fundamental geophysical and geologic interest in the polar and other unexplored regions; (iv) earth tide measurements and their relationship to geology and earth structure.

The gravity standardization measurements planned can be divided into two parts: (i) the establishment of a gravity reference standard using pendulum measurements and (ii) the establishment of an international network of gravity control bases. In connection with the first, work already has been started under the auspices of the Air Force Cambridge Research Center. Under this program, measurements are being made with the compound quartz pendulum equipment that was developed by the Gulf Research and Development Company. The work is being done by the University of Wisconsin–Woods Hole Oceanographic Institution group along north-south lines, and to date measurements have been completed between Fairbanks, Alaska, and Paso Cortez, Mexico, and between Oslo, Norway, and Capetown, Union of South Africa.

It is planned during the International Geophysical Year to initiate another line of measurements from Thule, Greenland, extending down the east coast of North and South America to Cape Horn, to extend the Alaska-Mexico line down the west coast of South America to Santiago, Chile, and to initiate a new line from the Aleutian Islands along the east coast of Asia through Australia to Antarctica. Complementary measurements at the same sites using the compound, magnetically compensated Invar pendulums of Cambridge University are also planned. In North America such additional measurements have already been made with the Cambridge pendulums at most of the Gulf pendulum sites by the Dominion Observatory of Canada. Some check measurements have also been made by the U.S. Coast and Geodetic Survey with their pendulum equipment.

It is significant that results for all three sets of equipment, which differ radically in design and material, are in excellent agreement over the entire range. Such pendulum measurements are essential not so much for their detailed accuracy, which will

probably be of the order of ±0.3 to 0.5 milligal, but because of their over-all accuracy in depicting the actual change in gravity associated with the earth. While it may be thought that this has been well established, this is not the case. Errors in excess of 30 milligals are not uncommon in the older pendulum gravity work, and with those pendulums made of Invar that were not magnetically compensated, it is known there are systematic errors related to changes in the earth's magnetic field that amount to more than 2.5 milligals per 1000 milligals change with latitude. Because of this uncertainty in the older pendulum work—the results have been used as a reference standard for calibrating spring-type gravimeters—no one knows how accurate the results obtained with such instruments are, particularly those obtained at high latitudes. The proposed series of pendulum measurements would give a basis for resolving this uncertainty and would give also a gravity reference standard that would be available throughout the world both for control purposes and for calibrating the gravimeters, which are much more convenient and economical to use.

In connection with the second portion of the standardization program, it is proposed to extend and verify key points in the world network of gravity bases established with gravimeters, principally by the Woods Hole Oceanographic Institution under the auspices of the Office of Naval Research and by the Expeditions Polaires Françaises. These measurements were planned as a means of (i) checking the accuracy of the various national gravity bases, (ii) establishing a world network of gravity bases for reference purposes so that existing gravity data taken by commercial, governmental, and academic groups could be tied into a common datum, and (iii) establishing regional control for future work in areas for which there are no data. To date, under the program conducted by the University of Wisconsin–Woods Hole Oceanographic Institution group, more than 3000 sets of measurements have been made in 85 countries. Despite this wide coverage, much of the earth has not been covered. For example, no measurements have been made in areas under communist control. It is hoped that during the IGY it will be possible to make sufficient measurements in those areas that have been politically inaccessible so that the data of these countries can be integrated into a unified whole with those of the rest of the world. If this can be done, much of the uncertainty concerning the actual shape of the earth (the geoid) and the geometric form the earth actually most closely approaches can be resolved.

In connection with observations in areas for which there are few or no existing data, one of the primary areas of study will be the oceanic areas. The Lamont Observatory of Columbia University has primary cognizance of this part of the program, and extensive submarine gravity measurements using Vening Meinesz compound pendulums are planned, particularly in the southern hemisphere, where there are very few data. Auxiliary marine measurements over the continental shelf area are planned by the University of Wisconsin group with on-bottom, remote-recording gravimeters. The purpose of these measurements is to try to get a better understanding of the nature of the structural transition from the continental blocks to the oceanic blocks. A third type of marine measurement will be those conducted from floating ice islands in the Arctic Ocean. Two such floating geophysical base stations are contemplated, and gravity measurements will be one part of the program at these sites. This work will be a continuation of the gravity program carried out under the auspices of the Air Force Cambridge Research Center on Fletcher's Ice Island (T-3). These measurements will be of considerable value in studying the geologic structure of the Arctic Ocean and in particular the submarine mountain range that was outlined by bathymetric measurements that were made from floating ice-floe bases by Soviet scientists.

Other Activities

Other gravity studies of significance in structural geology will be those conducted across island arcs, mountain ranges and similar tectonic units. These programs will be conducted both by the University of Wisconsin and by the Lamont Geological Observatory of Columbia University. Likewise, the earth tide measurement program of the University of California at Los Angeles using especially developed gravimeters sensitive to 0.001 milligal will be of interest to both geologists and geophysicists, for these measurements taken on a synoptic basis over the world will permit the elastic response of the earth to be studied and its variation with geology and crustal structure to be evaluated. These measurements as now planned would involve continuous observations for a 31-day period at each site selected for study.

In Antarctica, gravity measurements will be a part of the general glaciological program. Measurements will be carried out by four over-snow traverse parties of the Arctic Institute, who will conduct both seismic and gravity measurements as part of the study of the thickness of the ice and the nature of the underlying bedrock. The gravity measure-

ments will also serve as reference data for later check observations to determine possible wasting or accretion of the ice with time.

In addition to the afore-mentioned gravity studies, which all come under the official program of the U.S. National Committee for the International Geophysical Year, there will undoubtedly be other gravity studies which will be coordinated with this program by university groups and governmental agencies, for example, the Hydrographic Office of the Navy, the U.S. Geological Survey, and the U.S. Coast and Geodetic Survey.

ASSOCIATION AFFAIRS

Proposed Change in AAAS Constitution

For a number of years the American Association for the Advancement of Science has elected some scientific societies as affiliates and others as associates. The Association's Committee on Affiliation and Association recommends that the category of associates be dropped and that associated societies be offered the status of affiliates. To accomplish this change, it will be necessary to make a few changes in the Association's constitution:

1) Change the title of Article VIII from *Affiliates and Associates* to *Affiliated and Participating Organizations.*

2) Delete Section 3 of Article VIII.

3) Change the number of Section 4 of Article VIII to Section 3.

The Board of Directors approves these recommendations. They will be submitted to the Council for vote at the 1956 annual meeting in New York.

Traveling High-School Science Libraries

The Traveling High-School Science Library Program, now in its second year, is supported by a grant from the National Science Foundation and is administered by the AAAS. The program reflects the great interest of both agencies in assuring scientific manpower for the future and recognizes that most careers in science actually begin during high-school education. The majority of the high-school students in the United States live in localities where neither the school library nor the public library, if there are such libraries, afford adequate opportunity for recreational and collateral reading in the sciences and mathematics.

The general purposes of the program are to stimulate interest in reading science and mathematics books, to broaden the science background of high-school students, and to assist students with scientific interests in choosing careers in the sciences. In addition, although it is not a primary objective, the program acquaints teachers and librarians with books on science and mathematics that are suitable for general reading by high-school students and that would be appropriate acquisitions for the school or community library.

During 1955–56 the traveling library consisted of 150 books that were circulated to 66 high schools in various parts of the United States. The books and schools were reported in *The Scientific Monthly* [**82**, 51 (1956)] and in *Science* [**122**, 1173 (1955)]. Circulation records of the books maintained at each school were analyzed statistically. Questionnaires were completed by the 11th- and 12th-grade students at the program schools which gave their reactions to the program and their appraisal of the books in the library.

In 1956–57 the traveling library consists of 200 books: 112 of the 150 included in the 1955–56 library, and 88 new selections. The selections were based on the suggestions of more than 200 individuals made in the summers of 1955 and 1956, on the 1955–56 circulation records and summaries of student questionnaires, and on the suggestions and appraisals of the original list which were made by representatives of the following organizations.

AAAS, AAAS Cooperative Committee on the Teaching of Science and Mathematics, American Association of Physics Teachers, American Association of School Librarians, American Chemical Society, American Dental Association, American Institute of Biological Sciences, American Library Association, American Medical Association, American Meteorological Society, American Pharmaceutical Association, American Psychological Association, American Society of Agronomy, American Society of Limnology and Oceanography, Association of Geology Teachers, District of Columbia Public Library, Mathematical Association of America, National Association of Biology Teachers, National Research Council, National Science Foundation, National Science Teachers Association, National Society of Professional Engineers, New York Public Library, Society of American Foresters, Society of Systematic Zoology, Special Libraries

Association, U.S. Office of Education, and the Wildlife Society.

The number of excellent books recommended far exceeded the maximum of 200 that could be included in the library, and many decisions had to be made by the director of the program and his associates. A few recently published books that had not yet been brought to the attention of the advisory organizations and individuals were included. These will be evaluated by the program during the year. All the selected books have been reviewed by the director, and many were reviewed and appraised during the past summer by two young men, one a college freshman and the other a senior in high school.

Biography and autobiography, history of science and mathematics, and applied science are well represented in the 1956–57 library. An attempt has been made to provide a very broad range of subject matter so that a student may acquaint himself with the major branches of science and discern the practical application of the sciences and mathematics in research, in the professions, and in industry. As a rule, textbooks were not selected except when no trade books were available that covered the same subject matter. For obvious reasons, only books currently in print and available for purchase have been included.

The AAAS will evaluate the effectiveness of the Traveling Science Library Program and assess the interest of high-school students in the individual books in the library. This study will be based on the actual book circulation records at each school and on questionnaires to be completed by students at the program schools and at selected matching control schools that are not receiving the library.

A list of the 200 books in the present traveling library follows. Those that also were in the 1955–56 list of 150 are marked with an asterisk.

Books in the Libraries

Allen, D. L. *Our Wildlife Legacy.* Funk & Wagnalls, 1954.

*Alter, D., and C. H. Cleminshaw. *Pictorial Astronomy.* Crowell, 1952.

*Andrews, R. C. *Beyond Adventure: The Lives of Three Explorers.* Duell, Sloan and Pearce, 1954.

*Andrews, R. C. *This Amazing Planet.* Putnam's, 1940.

Archer, S. G. *Soil Conservation.* Univ. of Oklahoma, 1956.

Asimov, I. *Chemicals of Life.* Abelard-Schuman, 1954.

Asimov, I. *Inside the Atom.* Abelard-Schuman, 1956.

*Baitsell, G. A. (Ed.) *Science in Progress.* Yale Univ. *1st ser., 1939; 2nd ser., 1940; 3rd ser., 1942; *4th ser., 1945; *5th ser., 1947; *6th ser., 1949; *7th ser., 1951; *8th ser., 1953.

*Bakst, A. *Mathematics: Its Magic and Mastery.* Van Nostrand, 1952.

*Ball, M. W. *This Fascinating Oil Business.* Bobbs-Merrill, 1940.

*Bates, M. *The Prevalence of People.* Scribner's, 1955.

*Beebe, W. *Half Mile Down.* Duell, Sloan and Pearce, 1951.

Bell, E. T. *Men of Mathematics.* Simon and Schuster, 1937.

*Benedict, R. *The Chrysanthemum and the Sword.* Houghton Mifflin, 1946.

Berkeley, E. C. *Giant Brains or Machines That Think.* Wiley, 1949.

*Berrill, N. J. *Sex and the Nature of Things.* Dodd, Mead, 1953.

Bonestell, C., and W. Ley. *The Conquest of Space.* Viking, 1956.

Bonner, J. T. *Cells and Societies.* Princeton Univ., 1955.

*Borek, E. *Man, the Chemical Machine.* Columbia Univ., 1952.

Boucher, P. E. *Fundamentals of Photography.* Van Nostrand, 1955.

*Bremner, M. D. K. *The Story of Dentistry.* Dental Items of Interest, 1954.

*Bronowski, J. *The Common Sense of Science.* Harvard Univ., 1955.

*Buchsbaum, R. M. *Animals Without Backbones.* Univ. of Chicago, 1948.

*Burnet, M. *Natural History of Infectious Disease.* Cambridge Univ., 1953.

Campbell, M., and H. Hatton. *Herbert H. Dow: Pioneer in Creative Chemistry.* Appleton-Century-Crofts, 1951.

Carhart, A. H. *Timber in Your Life.* Lippincott, 1955.

*Carlson, A. J., and V. Johnson. *The Machinery of the Body.* Univ. of Chicago, 1953.

Carson, R. L. *The Edge of the Sea.* Houghton Mifflin, 1955.

*Carson, R. *The Sea Around Us.* Oxford Univ., 1951.

*Ceram, C. W. *Gods, Graves, and Scholars: The Story of Archaeology.* Knopf, 1954.

*Clapesattle, H. *The Doctors Mayo.* Univ. of Minnesota, 1954.

*Cohen, I. B. *Science, Servant of Man.* Little, Brown, 1948.

Coleman, J. A. *Relativity for the Layman.* William Frederick, 1954.

Future scientists assisted in the final selection of the traveling library books.

*Cooley, D. G. *The Science Book of Wonder Drugs.* Franklin Watts, 1954.

*Coombs, C. *Skyrocketing into the Unknown.* Morrow, 1954.

Cottrell, L. *The Mountains of Pharaoh.* Rinehart, 1956.

Coulter, M. C. *The Story of the Plant Kingdom.* Univ. of Chicago, 1935.

*Courant, R., and H. Robbins. *What is Mathematics?* Oxford Univ., 1941.

Cousteau, J. Y. *The Silent World.* Harper, 1953.

*Croneis, C., and W. C. Krumbein. *Down to Earth: An Introduction to Geology.* Univ. of Chicago, 1936.

*Curie, E. *Madame Curie.* Doubleday, 1953.

*Dantzig, T. *Number: The Language of Science.* Macmillan, 1954.

*Dean, G. *Report on the Atom.* Knopf, 1954.

de Kruif, P. *Men Against Death.* Harcourt, Brace, 1932.

*de Kruif, P. *Microbe Hunters.* Harcourt, Brace, 1932.

Diamond, F. *The Story of Glass.* Harcourt, Brace, 1953.

*Diebold, J. *Automation: The Advent of the Automatic Factory.* Van Nostrand, 1952.

Diole, P. *4000 Years Under the Sea.* Messner, 1954.

Dobzhansky, T. *Evolution, Genetics, and Man.* Wiley, 1955.

*Douglas, J. S. *The Story of the Oceans.* Dodd, Mead, 1952.

*Dubos, R. J. *Louis Pasteur: Free Lance of Science.* Little, Brown, 1950.

*Dubos, R., and J. Dubos. *The White Plague: Tuberculosis, Man and Society.* Little, Brown, 1952.

Durrell, G. M. *The Overloaded Ark.* Viking, 1953.

*Eaton, J. R. *Beginning Electricity.* Macmillan, 1952.

*Farber, E. *The Evolution of Chemistry.* Ronald, 1952.

Farber, E. *Nobel Prize Winners in Chemistry.* Schuman, 1953.

*Faxon, N. W. (Ed.) *The Hospital in Contemporary Life.* Harvard Univ., 1949.

*Fenton, C. L., and M. A. Fenton. *Giants of Geology.* Doubleday, 1952.

Fenton, C. L., and M. A. Fenton. *The Rock Book.* Doubleday, 1940.

Fenton, C. L. *Life Long Ago: The Story of Fossils.* John Day, 1937.

Fermi, L. *Atoms in the Family: My Life with Enrico Fermi.* Univ. of Chicago, 1954.

*Fox, R. *Great Men of Medicine.* Random House, 1947.

*Fox, R. *Milestones of Medicine,* Random House, 1950.

*Friend, J. N. *Man and the Chemical Elements.* Scribner's, 1953.

*Friend, J. N. *Numbers: Fun and Facts.* Scribner's, 1954.

*Gabrielson, I. N. *Wildlife Conservation.* Macmillan, 1952.

*Gamow, G. *The Moon.* Schuman, 1953.

*Gamow, G. *Mr Tompkins Explores the Atom.* Cambridge Univ., 1955.

*Gamow, G. *Mr Tompkins in Wonderland.* Cambridge Univ., 1953.

*Gamow, G. *One, Two, Three . . . Infinity.* Viking, 1954.

Garrett, H. E. *Great Experiments in Psychology.* Appleton-Century-Crofts, 1951.

*Glasstone, S. *Sourcebook on Atomic Energy.* Van Nostrand, 1950.

Glynn, J. H. *The Story of Blood.* Wyn, 1948.

Gollomb, J. *Albert Schweitzer: Genius in the Jungle.* Vanguard, 1949.

*Grabbe, P. *We Call It Human Nature.* Harper, 1939.

Grant, M. P. *Microbiology and Human Progress.* Rinehart, 1953.

*Gray, J. *How Animals Move.* Cambridge Univ., 1953.

*Grinter, L. E., H. N. Holmes, *et al. Engineering Preview.* Macmillan, 1947.

*Haggard, H. W. *Devils, Drugs, and Doctors.* Harper, 1929.

*Hamilton, W. J., Jr. *American Mammals:*

Their Lives, Habits and Economic Relations. McGraw-Hill, 1939.

Haynes, W. *Cellulose, the Chemical That Grows.* Doubleday, 1953.

Heathcote, Niels H. de V. *Nobel Prize Winners in Physics.* Schuman, 1953.

Hecht, S. *Explaining the Atom.* Viking, 1955.

*Hegner, R. *Parade of the Animal Kingdom.* Macmillan, 1955.

Herrmann, P. *Conquest by Man.* Harper, 1954.

*Heyerdahl, T. *Kon-Tiki: Across the Pacific by Raft.* Rand McNally, 1950.

Hochbaum, H. A. *Travels and Traditions of Waterfowl.* Univ. of Minnesota, 1955.

*Hogben, L. *Mathematics for the Million.* Norton, 1951.

*Holland, R., Jr. *The Physical Nature of Flight.* Norton, 1951.

*Hooten, E. A. *Up from the Ape.* Macmillan, 1946.

Howells, W. *Back of History: The Story of Our Own Origins.* Doubleday, 1954.

Hylander, C. J. *The World of Plant Life.* Macmillan, 1956.

*Jaffe, B. *Crucibles: The Story of Chemistry.* Simon and Schuster, 1951.

*Jaffe, B. *Men of Science in America.* Simon and Schuster, 1946.

*Kaempffert, W. *Explorations in Science.* Viking, 1953.

Kaplan, J., and W. Von Braun, *et al. Across the Space Frontier.* Viking, 1953.

Kasner, E., and J. Newman. *Mathematics and the Imagination.* Simon and Schuster, 1940.

*Kellogg, C. E. *The Soils That Support Us.* Macmillan, 1951.

*Kendall, J. *Great Discoveries by Young Chemists.* Crowell, 1953.

Killeffer, D. H. *Two Ears of Corn, Two Blades of Grass.* Van Nostrand, 1955.

*King, T. *Water: Miracle of Nature.* Macmillan, 1955.

Kinkead, E. *Spider, Egg, and Microcosm.* Knopf, 1955.

*Kraus, E. H., and C. B. Slawson. *Gems and Gem Materials.* McGraw-Hill, 1947.

Kuenen, P. H. *Realms of Water.* Wiley, 1955.

*Kugelmass, J. A. *J. Robert Oppenheimer and the Atomic Story.* Messner, 1953.

*Laird, C., and R. Laird. *Weathercasting.* Prentice-Hall, 1955.

*Lavine, S. A. *Steinmetz: Maker of Lightning.* Dodd, Mead, 1955.

*Levinger, E. E. *Albert Einstein.* Messner, 1949.

*Levinger, E. E. *Galileo: First Observer of Marvelous Things.* Messner, 1954.

Book publishers donated a reference collection of more than 1000 titles from which selections were made.

Ley, W. *Engineers' Dreams.* Viking, 1955.

Ley, W., and W. Von Braun. *The Exploration of Mars.* Viking, 1956.

*Lieber, L. R. *The Education of T. C. Mitts.* Norton, 1944.

Lieber, L. R. *Einstein Theory of Relativity.* Rinehart, 1945.

Lieber, L. R. *Infinity.* Rinehart, 1953.

*Logsdon, M. I. *A Mathematician Explains.* Univ. of Chicago, 1947.

Longstreth, T. M. *Understanding the Weather.* Macmillan, 1953.

Lorenz, K. Z. *King Solomon's Ring: New Light on Animal Ways.* Crowell, 1952.

*MacCurdy, E. (Ed. and Tr.) *The Notebooks of Leonardo Da Vinci.* Braziller, 1955.

*Macgowan, K. *Early Man in the New World.* Macmillan, 1953.

Meyer, J. S. *Fun with Mathematics.* World, 1952.

Mohr, C. E., and H. N. Sloane (Eds.) *Celebrated American Caves.* Rutgers Univ., 1955.

Moore, P. *The Story of Man and the Stars.* Norton, 1955.

*Morris, L., and K. Smith. *Ceiling Unlimited: The Story of American Aviation from Kitty Hawk to Supersonics.* Macmillan, 1953.

*Moulton, F. R., and J. J. Schifferes. *The Autobiography of Science.* Doubleday, 1953.

*Munn, N. L. *The Evolution and Growth of Human Behavior.* Houghton Mifflin, 1955.

Newman, J. R. *What Is Science?* Simon and Schuster, 1955.

*Norman, J. R. *A History of Fishes.* A. A. Wyn, 1948.

The traveling library is sent to program schools in display cases of 25 books each.

Ogilvy, C. S. *Through the Mathescope.* Oxford Univ., 1956.

*Payne-Gaposchkin, C. *Stars in the Making.* Harvard Univ., 1952.

*Peattie, D. C. *Flowering Earth.* Putnam's, 1939.

*Peterson, R. T., and J. Fisher. *Wild America.* Houghton Mifflin, 1955.

Pfeiffer, J. *The Changing Universe.* Random House, 1956.

*Pierce, J. R. *Electrons, Waves and Messages.* Hanover House, 1956.

Pinchot, G. *Breaking New Ground.* Harcourt, Brace, 1947.

Platt, R. *This Green World.* Dodd, Mead, 1942.

Pope, C. H. *The Reptile World: A Natural History of Snakes, Lizards, Turtles and Crocodilians.* Knopf, 1955.

Rapport, S., and H. W. Wright (Eds.) *Great Adventures in Medicine.* Dial, 1952.

*Reid, C. *From Zero to Infinity.* Crowell, 1955.

Reinfeld, F. *Uranium and Other Miracle Metals.* Sterling, 1955.

Rodahl, K. *North: The Nature and Drama of the Polar World.* Harper, 1953.

*Roe, A. *The Making of a Scientist.* Dodd, Mead, 1953.

*Rogers, B. A. *The Nature of Metals.* Iowa State Coll., 1951.

*Roueche, B. *Eleven Blue Men, and Other Narratives of Medical Detection.* Little, Brown, 1954.

Russell, F. S., and C. M. Yonge. *The Seas: Our Knowledge of Life in the Sea and How It Is Gained.* Frederick Warne, 1936.

Sanderson, I. T. *Follow the Whale.* Little, Brown, 1956.

Scientific American, (Eds.) *Scientific American Reader.* Simon and Schuster, 1953.

Sears, P. B. *Deserts on the March.* Univ. of Oklahoma, 1947.

Semat, H. *Physics in the Modern World.* Rinehart, 1949.

*Seton, E. T. *Trail of an Artist Naturalist.* Scribner's, 1948.

*Shapley, H., S. Rapport, and H. Wright. *A Treasury of Science.* Harper, 1954.

*Silverman, M. *Magic in a Bottle.* Macmillan, 1953.

*Simpson, G. G. *Life of the Past: An Introduction to Paleontology.* Yale Univ., 1953.

*Singer, C. *A History of Biology.* Schuman, 1951.

Skilling, H. H. *Exploring Electricity: Man's Unfinished Quest.* Ronald, 1948.

*Sloop, M. T. M. *Miracle in the Hills.* McGraw-Hill, 1953.

*Smart, W. M. *The Origin of the Earth.* Cambridge Univ., 1953.

*Smith, F. G. W., and H. Chapin. *The Sun, the Sea and Tomorrow.* Scribner's, 1954.

Smith, H. S. *The World's Great Bridges.* Harper, 1953.

*Sootin, H. *Isaac Newton.* Messner, 1955.

*Sootin, H. *Michael Faraday: From Errand Boy to Master Physicist.* Messner, 1954.

Spectorsky, A. C. (Ed.) *The Book of the Mountains.* Appleton-Century-Crofts, 1955.

Spectorsky, A. C. (Ed.) *The Book of the Sea.* Appleton-Century-Crofts, 1954.

*Spencer, S. M. *Wonders of Modern Medicine.* McGraw-Hill, 1953.

*Sproul, E. E. *The Science Book of the Human Body.* Franklin Watts, 1955.

Stevenson, L. G. *Nobel Prize Winners in Medicine and Physiology.* Schuman, 1953.

*Storck, J., and W. D. Teague. *Flour for Man's Bread: A History of Milling.* Univ. of Minnesota, 1952.

Storer, J. H. *The Web of Life: A First Book of Ecology.* Devin-Adair, 1956.

*Sullivan, J. W. W. *The Story of Metals.* Iowa State Coll., 1951.

Swezey, K. M. *Science Magic.* McGraw-Hill, 1952.

Tannehill, I. R. *The Hurricane Hunters.* Dodd, Mead, 1956.

Taylor, F. S. *An Illustrated History of Science.* Prager, 1955.

*Taylor, F. S. *A Short History of Science and Scientific Thought.* Norton, 1949.

*Teale, E. W. *Grassroot Jungles: A Book of Insects.* Dodd, Mead, 1950.

*Teale, E. W. (Ed.) *The Insect World of J. Henri Fabre.* Dodd, Mead, 1950.

Thomson, E. *Harvey Cushing: Surgeon, Author, Artist.* Schuman, 1950.

Townsend, G., and J. R. Dalzell. *How to Plan a House.* American Technical Society, 1952.

Untermeyer, L. *Makers of the Modern World.* Simon and Schuster, 1955.

Upton, M. *Electronics for Everyone: The Story of Electricity in Action.* Devin-Adair, 1955.

Vaeth, J. G. *200 Miles Up: The Conquest of the Upper Air.* Ronald, 1955.

Verne, J. *Twenty Thousand Leagues Under the Sea.* World, 1946.

*von Frisch, K. *The Dancing Bees.* Harcourt, Brace, 1955.

*Wallace, G. J. *An Introduction to Ornithology.* Macmillan, 1955.

*White, A. T. *Lost Worlds: The Romance of Archaeology.* Random House, 1941.

Wiener, N. *I Am a Mathematician.* Doubleday, 1956.

*Williams, B., and S. Epstein. *William Crawford Gorgas: Tropic Fever Fighter.* Messner, 1953.

Woodbury, D. O. *The Glass Giant of Palomar.* Dodd, Mead, 1954.

*Woodham-Smith, C. *Lonely Crusader: The Life of Florence Nightingale.* McGraw-Hill, 1951.

Yost, E. *American Women of Science.* Lippincott, 1955.

Young, A. *Scalpel: Men Who Made Surgery.* Random House, 1956.

Zim, H. S. *Plants.* Harcourt, Brace, 1947.

*Zinsser, H. *Rats, Lice and History: A Study in Biography.* Little, Brown, 1955.

Program Schools

During 1956–57, a total of 104 schools are participating in the Traveling Science Library Program. Twenty-six sets of the library are being circulated to the program schools, and two sets are being used for exhibition at scientific meetings and at meetings of teachers and librarians. Each school receives 50 books at a time. The books are used for two months. During the summer of 1957 the traveling libraries will be used at the institutes for science and mathematics teachers sponsored by the National Science Foundation.

The greatest apparent need for the traveling libraries is in small and medium-sized high schools in nonmetropolitan localities. Recommendations were solicited from state departments of education and from well-informed faculty members of universities and colleges. Each recommended school was informed of the program and invited to send information on its enrollment, curriculum, faculty, and library facilities, and to indicate whether it was interested in becoming a part of the program. The

The AAAS has published an annotated catalog of the traveling library. It is available to teachers and school librarians on request.

104 participants were selected from a much larger number of responses to afford a wide geographic distribution and to represent a diversity of local socioeconomic conditions. Most of the schools are in nonmetropolitan areas and have an enrollment of between 200 and 600 students in the ninth to 12th grades, inclusive. Both public and private schools are represented. Two large senior high schools in the Washington metropolitan area and an exceptional junior high school have been included for comparison. The 104 program schools are as follows.

Alabama: Baldwin County High School; J. U. Blacksher High School, Uriah; Choctaw County High School; Decatur High School; Montevallo High School; Randolph County High School; Semmes High School; West Blockton High School.

Arkansas: Bentonville High School; Harrison High School; Jacksonville High School; Ozark High School.

California: Calexico Union High School; Needles Union High School; Pomona Catholic High School; Santa Ynez Valley High School.

Colorado: Central High School, Grand Junction; Delta High School; Sheridan Union High School, Englewood; Holy Trinity High School, Trinidad.

Connecticut: Darien High School; Griswold High School, Jewett City; Housatonic Valley Regional High School, Falls Village; Watertown High School.

District of Columbia: Alice Deal Junior High School; Hebrew Academy of Washington; Woodrow Wilson High School.

Indiana: Chesterton High School; Lebanon Junior-Senior High School; Western High School, Russiaville; Tipton High School.

Iowa: Britt High School; Clarinda High School; Estherville High School; Sumner High School.

Louisiana: DeRidder High School; Haynesville High School; Minden High School; Natchitoches High School.

Maryland: Howard County High School; Northern Garrett County High School; Northwestern Senior High School, Hyattsville; Northwood Junior-Senior High School, Silver Spring; Walter Johnson Senior High School, Rockville; Wheaton Senior High School; Wicomico Senior High School, Salisbury; Wiley H. Bates High School, Annapolis.

Michigan: Holland Christian High School; Marlette Community High School; Newaygo High School; Okemos High School; Rodney Wilson High School, St. John's; Union High School, Greenville; Warren High School; Washington Gardner High School, Albion.

Minnesota: Cloquet High School; Detroit Lakes High School; Fergus Falls High School; Grand Rapids High School; Lourdes Central Catholic High School, Rochester; Mapleton High School; Northfield High School; Worthington Senior High School.

Montana: Anaconda Public High School; Beaverhead County High School, Dillon; Fergus County High School, Lewiston; Libby High School.

New York: Canandaigua Academy; Glens Falls High School; Herkimer Central High School; Hornell Senior High School; Interlaken Central School; Northside High School, Corning; Oneonta High School; Plattsburgh High School.

North Carolina: Bunker Hill High School, Claremont; Charity High School, Rosehill; Davis County High School; Highland High School, Gastonia; Jones Central High School, Trenton; North Davidson High School, Lexington; Price High School, Salisbury; Shepard High School, Zebulon.

North Dakota: Hettinger High School; Valley City High School; Wahpeton High School; Williston High School.

Oklahoma: Clinton High School; McAlester High School; Norman High School; Shawnee High School.

Texas: Killeen High School; Rio Grande City High School; Seguin High School; Weslaco High School.

Virginia: Bluestone High School, Chase City; Halifax County High School; Martinsville High School; Robert E. Lee High School, Staunton; St. Stephen's School, Alexandria.

West Virginia: Dunbar High School; Sherman High School, Seth; Sophia High School; Sutton High School.

Basic List of Science Books for High Schools

The AAAS has published a descriptive catalog of the books in the traveling libraries which is available to teachers and high-school librarians on request. This book list, although limited in scope, proved to be in demand last year as a guide for purchasing books for school and community libraries.

The AAAS, with the cooperation of the National Science Foundation, plans to publish late in 1957 a basic list of science and mathematics books for high-school libraries and other libraries used by young people. The number of titles in the proposed book list will not be limited, and the list will include the kinds of books in the traveling library, as well as standard reference books, natural history keys and field guides, and a selected group of basic textbooks. The list will be based on the many suggestions for the traveling library made by individuals and representatives of organizations and will be compiled by a small committee of specialists in the teaching of science and mathematics, library supervisors, and others. Such a list will meet a need frequently mentioned by school officers, teachers, and librarians.

The AAAS solicits the comments and suggestions of students, teachers, librarians, scientists, and others concerning the traveling library program, and will be glad to receive comments concerning books now in the traveling library or books not in the traveling library that are suggested for the basic book list. In suggesting books, kindly list the author, title, and publisher to facilitate the identification and examination of your suggestions and recommendations.

HILARY J. DEASON
High School Science Library Program, AAAS

Moving Frontiers of Science

"Moving frontiers of science" will be the theme of the AAAS general symposium at the coming New York meeting. The afternoons of 27 and 28 Dec. will be devoted to a discussion of the fundamental units and concepts of science. Representatives of the physical, the biological, and the social sciences will analyze their own areas of science in terms of the fundamental units, variables, or concepts with which each is concerned. Because these special sessions will be of Association-wide interest, there will be no conflicting programs of the separate

AAAS sections, and most of the 55 participating societies have also kept these afternoons free.

The program on the afternoon of 27 Dec. will open with a brief panel discussion that is expected to point out some of the topics that will be considered by later speakers and to raise questions concerning the differences in what constitute fundamental units or concepts of different fields of science. Members of the panel will be Paul Weiss of the Rockefeller Institute for Medical Research, Paul F. Lazarsfeld of the department of sociology at Columbia University, and Jerome B. Wiesner, director of Electronics Laboratory, Massachusetts Institute of Technology.

Following the opening panel discussion will be four addresses, the first three by spokesmen for the physical, biological, and social science areas: Jerrold R. Zacharias, professor of physics and head of the laboratory of nuclear science at Massachusetts Institute of Technology, will represent the physical sciences; R. W. Gerard, of the mental health research institute of the University of Michigan, will represent biological science; and Robert B. MacLeod, Sage professor and formerly chairman of the department of psychology at Cornell University, will represent social science.

The fourth address will be by Michael Polanyi, professor of social studies at Victoria University, Manchester, England, and formerly member of the Kaiser Wilhelm Institute for physical chemistry and professor of physical chemistry at Victoria University, who will compare and contrast the positions taken by the representatives of the three broad areas of science.

The program will end with a panel discussion that will include the three original panelists and the four speakers and will provide an opportunity for the consideration of selected questions that may be presented from the floor. Chairman and moderator will be Howard Mumford Jones, chairman, American Council of Learned Societies.

The program was arranged by the Committee on AAAS Meetings and the secretaries of the AAAS sections. Meeting together last spring, the committee and the section secretaries decided that at each annual meeting—for as long as the idea seems to be a good one—there should be one or more special sessions for the Association as a whole. The title "Moving frontiers of science" was adopted for these sessions, which, after this first year, are planned to consist of reports of research trends and findings that are of such broadly ramifying nature as to be of concern to many branches of science. The special program on fundamental units and concepts of science was planned to start the new series of programs.—RAYMOND L. TAYLOR.

Some Programs at the New York Meeting

Some of the section and society programs to be presented at the 1956 AAAS meeting in New York are given in the following pages. Others will be announced from time to time in *Science*, beginning with the issue of 23 November.

AAAS Special Sessions

Joint annual address of the Society of the Sigma Xi and the Scientific Research Society of America; 27 Dec.; Joseph W. Barker, Research Corporation, presiding. "Technology and society," by Lawrence R. Hafstad, General Motors Corporation. Wallace R. Brode, National Bureau of Standards, will award the William Procter prize.

Annual address of United Chapters of Phi Beta Kappa; 27 Dec.; Kirtley F. Mather, Harvard University, presiding. "Toward more vivid utopias," by Margaret Mead, American Museum of Natural History.

AAAS presidential address; 28 Dec.; Paul B. Sears, Yale University, presiding. "The uniqueness of man," by George W. Beadle, California Institute of Technology. Preceding the address, Eugene Holman, Standard Oil Company (N.J.), and general chairman of the New York meeting, will speak briefly. Following the address there will be an informal reception in the Hotel Statler. All registrants and members of the local committees are invited to attend.

Annual lecture and film of the National Geographic Society; 29 Dec.; Paul B. Sears, Yale University, presiding. "Southeast Asia's golden pageantry," by W. Robert Moore, Foreign Editorial Staff, National Geographic Society.

Engineering

Section M. Three-session symposium, cosponsored by Sections C, H, I, K, L, N and the Conference on Scientific Manpower; "Aids for environmental control"; arranged by Eugene F. Murphy, Veterans Administration, New York, N.Y., and Irving P. Orens, Newark College of Engineering. Part I, "Overcoming normal and abnormal physical limitations"; 26 Dec.; Eugene F. Murphy, presiding. Speakers: Max W. Lund, Office of Naval Research; Wallace E. Frank, Franklin Institute; Anthony Staros and William Romahn, Veterans Administration, New York, N.Y., and Rudolph Drillis, New York University. Discussant: Renato Contini, New York University. Part II, "Extending mental and rational powers"; 26 Dec.; Irving P. Orens, presiding. Speakers: Chas. Murray Gratz, New York, N.Y., John R. Ragazzini, Columbia University; R. W. Hamming, Bell Telephone Lab-

oratories. Discussant: Frederick A. Russell, Newark College of Engineering. Part III, "Breaking the language barriers"; 27 Dec.; John Lotz, Columbia University, presiding. Speakers: Sidney Friedrich, Republic Aviation Corporation; Sze-Hou Chang, Northeastern University; Victor H. Yngve, Massachusetts Institute of Technology; Anthony G. Oettinger, Harvard University. Discussants: Charles Ritter, American Foundation for the Blind; F. S. Cooper, Haskins Laboratories; Kenneth N. Stevens, Massachusetts Institute of Technology; Homer Dudley, Bell Telephone Laboratories; G. S. Fielstra, New York Public Library.

Geology and Geography

Section E, cosponsored by the Geological Society of America. Contributed papers, general geology; 26 Dec.

Three-session symposium, cosponsored by the American Geophysical Union, "Recent advances in geochronometry"; arranged by J. Laurence Kulp, Lamont Geological Observatory, Columbia University. Part I, 26 Dec.; J. Laurence Kulp, presiding. Speakers: George W. Wetherill, Carnegie Institution; Leon E. Long, Lamont Geological Observatory; Joseph Lipson, University of California; Paul W. Gast, Lamont Geological Observatory; Randall F. Cormier, Massachusetts Institute of Technology. Part II, 27 Dec.; George W. Wetherill, Carnegie Institution, presiding. Speakers: George R. Tilton, Carnegie Institution; Lorin R. Stieff, U.S. Geological Survey; Ron M. Farquhar, University of Toronto; David Gottfried, U.S. Geological Survey; Claire C. Patterson, California Institute of Technology. Part III, cosponsored by Sections F, G, H, 28 Dec., J. Laurence Kulp, presiding. Speakers: Wallace S. Broecker, Lamont Geological Observatory; Richard F. Flint, Yale University; Hallam L. Movius, Jr., Harvard University; James R. Arnold, Princeton University.

Symposium, "Carbonate sedimentation"; arranged by Rhodes W. Fairbridge, Columbia University, who will preside; 26 Dec. Speakers: Frank W. Beales, University of Toronto; Rhodes W. Fairbridge; John Imbrie, Columbia University; Norman D. Newell and John Imbrie, Columbia University; Seymour O. Schlanger, U.S. Geological Survey; Karl K. Turekian, Yale University; Theodore R. Walker, University of Colorado; R. J. Dunham, Shell Development Company.

Two-session symposium, "Ground water"; arranged by A. Nelson Sayre, U.S. Geological Survey, who, with Henry C. Barksdale, U.S. Geological Survey, will preside; 29 Dec. Speakers: Part I, A. N. Sayre, U.S. Geological Survey; Irwin Remson, J. R. Randolph, and H. C. Barksdale, U.S. Geological Survey; John G. Ferris and A. Nelson Sayre, U.S. Geological Survey; Wilbur T. Stuart, U.S. Geological Survey; N. M. Perlmutter, J. L. Geraghty, and J. E. Upson, U.S. Geological Survey; N. J. Lusczynski, U.S. Geological Survey. Part II, R. M. Leggette, Leggette, Brashears and Graham, New York, presiding. Speakers: J. E. Upson; R. V. Cushman, U.S. Geological Survey; J. F. Hoffman, U.S. Geological Survey; Sidney Paige, Columbia University; George C. Taylor, Jr., U.S. Geological Survey.

Vice-presidential address, "The training of a geologist," by Carl Tolman, Washington University; and Smoker; 29 Dec.

Two-session symposium; "Appalachian stratigraphy and structure"; arranged by John Rodgers, Yale University, who will preside; 30 Dec. Part I, speakers: C. R. L. Oder, American Zinc Company of Tennessee; John E. Sanders, Yale University; Leland F. Grant and John M. Kellberg, Tennessee Valley Authority; C. E. Prouty, University of Pittsburgh; David Hawley, Hamilton College; Bradford Willard, Lehigh University; Eleanora B. Knopf, Stanford University; Herbert P. Woodward, Rutgers University. Part II, speakers: Wallace M. Cady, U.S. Geological Survey; P. H. Osberg, Colby College; E-an Zen, Howard University; John L. Rosenfeld and Gordon P. Eaton, Wesleyan University; James B. Thompson, Jr., Harvard University; Alonzo W. Quinn, Brown University; Howard W. Jaffe, W. L. Smith, and C. L. Waring, U.S. Geological Survey; Robert B. Neuman, U.S. Geological Survey; James W. Clarke, University of South Carolina; B. Ashton Keith, Institute of Sciences, Washington, D.C.

Association of American Geographers' cosponsored by Section E. Invited papers, "Geographical research in progress"; arranged by John E. Brush, Rutgers University, and David H. Miller, Quartermaster Research and Development Center. Part I, 27 Dec.; William L. Thomas, Jr., Wenner-Gren Foundation, presiding. Speakers: David H. Miller; Walter Wood, Quartermaster Research and Development Center; Arthur F. Loeben, University of Pennsylvania; Jean Gottmann, Twentieth Century Fund, New York. Part II, 28 Dec.; Peter M. Stern, Conservation Foundation, presiding. Speakers: Robert Anstey, U.S. Army Quartermaster Corps Research and Development Center; Stanton J. Ware, Drexel Institute Laboratory of Climatology; Calvin J. Heusser, American Geographical Society of New York; Ivan Bennett, Quartermaster Research and Development Center.

National Speleological Society. General session, 29 Dec.

Physics

Section B, cosponsored by Sigma Pi Sigma. Symposium, "Optics and oriented nuclei"; arranged by William B. Hawkins, Yale University; Francis Bitter, Massachusetts Institute of Technology, presiding; 26 Dec. Speakers: William B. Hawkins; Peter Bender, National Bureau of Standards; Hans Dehmelt, University of Washington; Peter Buck, Columbia University.

Symposium, "Optical absorption in solids"; arranged by William F. Meggers, National Bureau of Standards, who will preside; 26 Dec. Speakers: Herbert P. Broida and Arnold M. Bass, National Bureau of Standards; Elias Burstein, Naval Research Laboratory; G. H. Dieke, Johns Hopkins University; Henry W. Morgan, Oak Ridge National Laboratory.

Vice-presidential address, "Science in society today," by Alan T. Waterman, National Science Foundation; 26 Dec.

Two-session symposium, "Diffusion in solids"; arranged by H. B. Huntington, Rensselaer Polytechnic Institute, who will preside; 27, 28 Dec. Part I, speakers: David Lazarus, University of Illinois; Lawrence S. Darken, U.S. Steel Corporation; Norman Nachtrieb, University of Chicago; David Turnbull, General Electric Company. Part II, speakers: Frank E. Jaumot, Franklin Institute; Howard W. Etzel, Naval Research Laboratory; F. J. Morin, Bell Telephone Laboratories; Arthur S. Nowick, Yale University.

Two-session symposium, "Crystal growth"; arranged by Nicolas Cabrera, University of Virginia; 29 Dec. Part I, David Turnbull, General Electric Laboratory, presiding; speakers: Bruce Chalmers, Harvard University; William G. Pfann, Bell Telephone Laboratories; W. C. Dash, General Electric Laboratory; W. A. Tiller, Westinghouse Research Laboratories; G. W. Sears, General Electric Laboratory. Part II, H. C. Herring, Bell Telephone Laboratories, presiding; speakers: Nicolas Cabrera, University of Virginia; G. W. Sears, General Electric Laboratory; R. G. Treuting and S. N. Arnold, Bell Telephone Laboratories; R. V. Coleman, University of Virginia; R. L. Eisner, Westinghouse Research Laboratories.

Gordon Research Conferences

Dinner and address, "The future through science," by Glenn T. Seaborg, University of California, in celebration of the 25th anniversary of the Gordon Research Conferences; Emil Ott, Food Machinery and Chemical Corporation, presiding; 27 Dec.

History and Philosophy of Science

Section L. Contributed papers; 26 Dec.

Two-session symposium, cosponsored by the Philosophy of Science Association, "Science and ethics"; arranged by Joseph Mayer, Miami University. Part I, 26 Dec.; Margaret Mead, American Museum of Natural History, presiding. Speakers: Joseph Mayer, Miami University; Anatol Rapoport, University of Michigan; Patrick Romanell, University of Texas. Part II, 26 Dec.; Ralph W. Gerard, University of Michigan, presiding. Speakers: John Dashiell, University of North Carolina; Chauncey D. Leake, Ohio State University; Margaret Mead; Edmund W. Sinnott, Yale University.

Symposium, joint with the American Philosophical Association, Eastern Division, "The general significance of the work of Freud"; arranged by John Wild, Harvard University, and Jane M. Oppenheimer, Bryn Mawr College; 27 Dec.; Lawrence S. Kubie, Yale University School of Medicine, presiding. Speakers: Ernst Kris, New York, N. Y.; Herbert Marcuse, Brandeis University; Philip Rieff, Brandeis University. Discussants: John A. Irving, University of Toronto; James G. Miller, University of Michigan.

History of Science Society, cosponsored by Section L. Symposium, "The interaction of science and technology"; arranged by Pearl Kibre, Hunter College; 28 Dec.; Henry Guerlac, Cornell University, presiding. Speakers: Cyril S. Smith, University of Chicago; John J. Beer, Hanover College; Frederick Kilgour, Yale University Medical School. Comment by Bern Dibner, Burndy Engineering Library, Norwalk, Conn.

Session on "Studies in modern science"; 28 Dec.; R. B. Lindsay, Brown University, presiding. Speakers: Marie Boas, Brandeis University; Thomas S. Kuhn, University of California; Lee M. Pearson, U.S. Department of Navy. Comment by Henry Noss, New York University.

Session on "Studies on medieval science"; 29 Dec.; Chauncey D. Leake, Ohio State University, presiding. Speakers: Marshall Clagett, University of Wisconsin; Curtis Wilson, St. John's College; William H. Stahl, Brooklyn College. Comment by Edward Rosen, City College of New York.

Session on "The history of medicine"; 29 Dec.; John F. Fulton, Yale University School of Medicine, presiding. Speakers: J. B. deC. M. Saunders, University of California School of Medicine; Genevieve Miller, Western Reserve University; Lynn Thorndike, Columbia University.

BOOK REVIEWS

The Laws of Nature. R. E. Peierls. Scribner's, New York, 1956. 284 pp. Illus. $4.50.

R. E. Peierls has attempted to introduce the nonmathematical reader to classical, modern, and very modern physics—up to but not including the discovery of the antiproton. The soundness of his account is guaranteed by his position as one of England's leading mathematical physicists. But Peierls' success in achieving his explicit objective is more difficult to evaluate.

The book will interest and instruct more than the beginner in physics. Readers with some knowledge of the material covered will be impressed by an orderly and economical style that proceeds unhampered—and unhelped—by imagery. Here is the abstractness of mathematics without the special symbolism. But the reader for whom *The Laws of Nature* is primarily intended may find that many passages require rereading, and that sometimes rereading does not help. The difficulty is that understanding in physics seems to require a special mixture of several elements. It requires a comparison of the new and unfamiliar with the familiar; it requires an appreciation of the mathematical ideas employed in the expression of physical laws; and it requires some acquaintance with the pieces of apparatus used in obtaining evidence. The educated layman who reads this book will have to be of exceptional fortitude, for he will undergo an education considerably more austere than that normally encountered at the start of an academic education in physics.

There are illustrations, but in some cases they are so bare that it is difficult to determine what is being illustrated.

JOSEPH TURNER

AAAS

The Men behind the Space Rockets. Heinz Gartmann. McKay, New York, 1956. 185 pp. Plates. $3.95. (Translated from *Träumer, Forscher, Konstrukteure, Econ-Verlag, Dusseldorf* by Eustace Wareing and Michael Glenny).

Throughout the literature of diverse ancient cultures are fanciful descriptions of voyages to heavenly bodies. This universal desire for exploration beyond the confines of the earth's surface received a basis for its potential realization in 1687 when Isaac Newton formulated his third law of motion. That action and reaction are equal and directed in opposite directions is the fundamental basis of the operation of rocket motors in the void beyond the atmosphere. Indeed, Newton may be included among the earliest of the space enthusiasts when he wrote: "This is the principle which will enable mankind in later centuries to undertake flight to the stars."

Heinz Gartmann's narrative is not concerned with the early history of rocketry, primitive forms of which are to be found in Chinese manuscripts of the 13th century. It starts about 1885 with a description of the dreams, aspirations, and accomplishments of a group of near contemporary visionaries, theoreticians, and experimentalists whose individual, and often overlapping efforts culminated in the present-day high-altitude military and space-probing rockets. The story begins with Hermann Ganswindt and his bold plans for a helicopterlike flying machine and a rocket propelled "cosmic vehicle"—proposed some 20 years before the first successful flight of the Wright brothers. The story unfolds with the contributions of Konstantin Tsiolkovski, Hermann Oberth, and the American physics professor, Robert H. Goddard to the development of liquid-fuel rocket motors, the principle of rocket staging, and the conception of an orbital satellite as a space station for interplanetary flight.

A large portion of the book is devoted to the activities of the German Rocket Society between the late 1920's and early 1930's. A period, according to Gartmann, when the "rocket and space travel mania reached its height." The work of Max Valier on the rocket propulsion of ice sleds to velocities of 242 miles per hour is of particular interest in view of the current utilization of similar techniques as a means for subjecting human bodies and airplane equipment to large accelerative forces at the Holloman Aero Medical Laboratory. An outstanding feature of this period of unsponsored rocket experimentation was the wealth of experience gathered by a small group of private enthusiasts operating on a shoestring budget.

Gartmann also describes the researches of Eugen Sänger, Helmut von Zborowski, and Wernher von Braun, which culminated in the V-2 long-range missile. Subsequent work on rockets of American design, such as the Aerobee and the Viking, receive only brief mention. The book is brought to date by outlines of von Braun's proposal for a manned satellite space station and the plans for the launching of miniature instrument-carrying satellites dur-

ing the approaching International Geophysical Year.

An important aspect of the book is the insight it provides into the social background, character, and mode of thinking of the devotees of space rocketry. The diverse personalities described bring to mind a statement made by James Clerk Maxwell on the feelings of the scientific community of theoreticians and experimentalists toward their work: "There are . . . some minds which can go on contemplating with satisfaction pure quantities presented to the eye by symbols, and to the mind in a form which none but mathematicians can conceive. . . . Others, again are not content unless they can project their whole physical energies into the scene which they conjur up. They learn at what rate the planets rush through space, and they experience a delightful feeling of exhilaration. They calculate the forces with which the heavenly bodies pull on one another and they feel their own muscles straining with the effort." Heinz Gartmann, who has participated in the early rocket research in Germany, has provided the reader with an informative, interestingly written history of an important period in rocket development.

HERMAN YAGODA

National Institutes of Health

Genetics in the Atomic Age. Charlotte Auerbach. Essential Books, Fair Lawn, N.J., 1956. viii + 106 pp. Illus. $2.

Rarely does a book so thoughtfully planned and so skillfully written for the nonscientific public as this one make an appearance. No one could write more authoritatively on the subject than Charlotte Auerbach, who is widely known among all geneticists as the discoverer of the first potent chemical mutagenic agent, mustard gas. But even if, among geneticists, there are a few others who could discuss the subject with equal authority, there is certainly no one who could write an account so unfailingly clear and so fresh in style, so pointed in its comprehension of the relevance of genetics to atomic dangers. The book is enlivened by humorous and effective diagrams done by I. G. Auerbach.

The subjects discussed include the effects of radiation on living organisms, the nature of mutations and their effects, "the dance of the chromosomes" in sexual reproduction, the detection and transmission of new mutations, the role of mutation in evolution, the production of mutations by x-rays and their types and frequencies in relation to x-ray dosage, and, finally, a consideration of the "genetically permissible" dose of radiation. An appendix contains definitions of the scientific terms used in the book.

No more fateful reports and recommendations for official consideration have been made than the two reports issued in June 1956, one in this country by committees of the National Academy of Sciences on "The biological effects of radiation" [*Science* **123,** 1110, 1157 (1956); **124,** 13, 17, 60, 63, 105 (1956)], the other in Great Britain by a committee of the Medical Research Council, entitled "The hazards to man of nuclear and allied radiations" [*Science* **124,** 101, 112 (1956)]. Both reports focus major attention on the genetic hazards of radiation. For nonscientists who need some background for the appreciation of those reports and recommendations, *Genetics in the Atomic Age* will supply an ideal introduction.

BENTLEY GLASS

Department of Biology,
Johns Hopkins University

Public Works and Employment from the Local Government Point of View. E. C. McKean and H. C. Taylor. Public Administration Service, Chicago, Ill., 1955. xiii + 274 pp. Illus. $5.

This study, a report of the W. E. Upjohn Institute for Community Research, was designed to assess the importance of public works in a context both of long-range planning for economic stabilization and of providing employment during periods of recession or depression in economic activity. Although its general approach is analytic with respect to local situations, it is not without implicit reference to macroeconomics. The conclusions, at least for several economists and public officials, will be somewhat startling, since the authors reply in the firm negative to the question of public works being particularly useful, either for contracyclical planning or during ad hoc contractions in the business cycle.

Both empirical and a priori arguments document the negation of the public works thesis to the extent of seeming to convince, at least me. This is not to say, however, that the authors are especially siding against public works projects per se. Although care is taken to stress the doubt of public works as an economic stimulus or mass provider of employment, there is, nonetheless, sufficient emphasis on the usefulness of public works to the community and to the nation, assuming well-defined needs for specific projects. There is, in addition, adequate discussion of methods of financ-

ing such projects on either "pay-as-you-go" or longer-term borrowing—or leasing—bases. In fact, the positive thesis of this study relevant to public works might be defined as "build-as-needed" and "pay-as-you-go" so far as current revenues can bear the burden. And the corollary thesis would seem to be, as far as employment is concerned, that public responsibility in periods of economic depression requires that direct relief and work relief measures precede public works measures in alleviating those in serious need—all financed by the government sector of the economy.

Strength would have been given to this undertaking if the role of the private sector of the economy in recession periods had been given adequate treatment. The *overtones* of the study are Keynesian, particularly as manifested in the deficit spending concept as public policy. It can be generously granted, however, that the scope of the material was intended to be narrow and exhaustive within its own confines, and that a broader discussion of fiscal policy and the business cycle was quite beyond the case in point.

For economists who will be challenged by the conclusions of the authors, this book will provide interesting reading. Officials and students of public administration, engaged in planning public works at the national or local levels, or otherwise, will find background information worthy of perusal. And finally, thoughtful lay readers will obtain provocative material of vital importance, should economic history repeat itself.

DONALD P. RAY
National Academy of Economics and Political Science, George Washington University

A Field Guide to the Ferns and Their Related Families of Northeastern and Central North America with a Section on Species also Found in the British Isles and Western Europe. Boughton Cobb. Houghton Mifflin, Boston, 1956. 281 pp. Illus. $3.75.

Unlike most of the earlier field guides in the series edited by Roger Tory Peterson, this one was written by a businessman. Boughton Cobb's hobby for many years has been the ferns, and he has not only studied them extensively over North America, Puerto Rico, and parts of Europe, but has raised them at home in a special fern garden. In this tenth *Field Guide* he shares his pleasures and offers help to outdoorsmen in finding names for the kinds they see.

Almost a hundred species receive careful treatment, about a fourth of them members of the "related families," which are the subphyla to which the horsetails, club mosses, and quillworts belong. Most species rate a pair of pages: a right-hand page with fine line drawings by Laura Louise Foster, and a facing page with systematized information. Diagnostic arrows point to features of the drawings which are important in identification. Keys and other aids, with further clear illustrations, assist in making the correct choice.

Many people who, like us, begin by being puzzled over the combination of geographic localities represented, will come to realize that the five pages devoted to European ferns and allies would not go far toward presenting the many species from western and southern North America. And "almost one half of the ferns and their allies described in this *Field Guide* may also be found in western Europe and/or the British Isles. This group constitutes more than half the total species that are listed for Europe and the British Isles." Hence the Cobb work will be highly useful across the ocean as well.

LORUS J. and MARGERY MILNE
Department of Zoology, University of New Hampshire

The Condensed Chemical Dictionary. Arthur and Elizabeth Rose. Reinhold, New York; Chapman and Hall, London, ed. 5, 1956. 1201 pp. $12.50.

The 30,000 entries in the fifth edition of *The Condensed Chemical Dictionary* cover subjects ranging from "alphabet soup" to names of textiles and trade names. Data on the chemical and physical properties of chemicals and raw materials, information on containers, shipping regulations, and safety instructions, new uses of chemicals in nuclear energy, chemotherapy, and other fields of current interest are included.

The information about trade marks and trade names has been expanded and revised by the use of new material obtained direct from the manufacturers. A list of 355 companies from whom the editors obtained detailed information regarding their products is included.

Articles appear in a straight alphabetical arrangement. Entries containing numbers only are listed after the Z entries. Otherwise, numbers are ignored in making the alphabetical arrangement. The volume is thumb indexed.

The first edition appeared in 1919; thus, the fifth edition marks 37 years of service to those who work with the chemical and process industries.

International Encyclopedia of Unified Science. vol. 1, pts. 1 and 2. Otto Neurath, Rudolf Carnap, and Charles Morris, Eds. University of Chicago Press, Chicago, Ill., 1955. 760 pp. $6 each; $11 for 2 vols.

A fair case could be made for the point of view that science is not progressing conceptually as rapidly as might be expected from current research effort and expenditure. An even stronger case might be advanced to explain the deficiency in terms of the amount of effort devoted to specialized experimentation in relation to speculative, analytic, and empirical thinking. The phenomenal expansion of technologic and scientific experimentation and development misleads us into assuming that our basic conceptual framework in science has grown in proportion. These volumes will help to refute any such assumption by highlighting the voids and incomplete phases of our knowledge; indeed, this is one of the purposes of the project.

The emphasis on specialization has also led to diffusion, has increased the problem of communication, and has slowed fundamental progress by reducing the impact of the thinking and discoveries in one narrow discipline on other scientific disciplines—even others in the same science. The creation of particulate terminology and symbolism has added a further barrier to interdisciplinary fertilization. The need for a unifying framework for science is, for all these reasons, both urgent and of primary importance.

The term *encyclopedia* as used in this title could be misleading to some. This first volume, at least, is not composed of short accounts of highly specific items but, rather, of broad philosophic reviews of the important constituents of unified science. Since subsequent volumes are to cover more specialized phases, they may take a more orthodox encyclopedic form.

Otto Neurath, in his introductory essay, emphasizes that the basic purpose of the encyclopedia is to further all kinds of scientific synthesis, which, he maintains, is one of the most important aims of the unity of science movement. The fruits of such unifying syntheses cannot be formulated into one "super science"; therefore, an encyclopedia of the methods, tools, and the various elements of the unifying process is the best medium of coordination.

He goes on to explain that there will be no effort to present one "program," completely agreed upon, but that, through the cooperation of scientists, there will be an effort to "elaborate the framework of unified science." Two paragraphs from the Neurath introduction form a succinct statement of what the encyclopedia aims to accomplish:

"The general purpose of the *International Encyclopedia of Unified Science* is to bring together material pertaining to the scientific enterprise as a whole. The work will not be a series of alphabetically arranged articles; rather will it be a series of monographs with a highly analytical index, which will make it possible to find the bit of information sought if the *Encyclopedia* is to be used as a reference work. Each monograph, sometimes written by more than one collaborator, is devoted to a particular group of problems. The collaborators and organizers of this work are concerned with the analysis and interrelation of central scientific ideas, with all problems dealing with the analysis of sciences, and with the sense in which science forms a unified encyclopedical whole. The new *Encyclopedia* so aims to integrate the scientific disciplines, so to unify them, so to dovetail them together, that advances in one will bring about advances in the others.

"The *Encyclopedia* is to be constructed like an onion. The heart of this onion is formed by twenty pamphlets which constitute two introductory volumes. These volumes, entitled *Foundations of the Unity of Science,* are complete in themselves but also serve as the introduction to what will follow."

The editors have adopted the broadest kind of definition of science, including the social sciences. In these introductory volumes they have gone even further and dealt extensively with the interrelations of science and the humanistic disciplines as well as social science-science relationships. As one would expect, the origins and roots of science in philosophy are explored; what will be newer to many is the treatment of the influence of imagination and of the social sciences on the development of unified science.

Great emphasis is placed on the perfecting of the tools of science. Carnap elaborates on the need for precise definitions in science and the relationships of such definitions in the various disciplines. Progress depends on resolving differences in scientific language. Treatments of the theory of signs, of logic and mathematics, and of linguistics make major contributions to the basis for unification of the sciences as well as the advancement of their more prescribed units.

Part 1 includes contributions by Otto Neurath, Niels Bohr, John Dewey, Bertrand Russell, Rudolf Carnap, Charles W. Morris, Leonard Bloomfield, and Victor F. Lenzen. Part 2 includes contributions by Ernest Nagel, Philipp Frank, E. Finlay-Freundlich, Felix Mainx, and Egon Brunswik.

The possibility of unity of the laws of science is far in the future, and we cannot be sure that it will ever be attained. The unity of the language of science can be achieved; without a unified language, there is no hope of fabricating a unity of laws; there-

fore, serious efforts should be continued to perfect a unified language.

These volumes represent a major contribution to the movement for a unified science. It is rather difficult to visualize how an effort of this kind can become, as Neurath hoped, "a platform for the discussion of all aspects of the scientific enterprise." It may avoid becoming a "mausoleum or herbarium," but a printed book, even of encyclopedic proportions, is a crystallization in time and can serve only as a source of information and ideas and a catalyst for thought and discussion leading to new crystallizations, albeit extensive rewritings of the original.

Unfortunately, all too few of the community of scientists of all kinds are interested in much more than their own specialties. We can only hope that a fair number of the more thoughtful of them will read these volumes, cogitate over their contents, and contribute leadership in the development of unified science.

JOHN A. BEHNKE

Ronald Press Company

An Essay on the Foundations of Geometry. Bertrand A. W. Russell. Dover, New York, 1956. 201 pp. $1.50, paper. (Unaltered republication of the first edition).

In his early years, when he was still holding to the philosophic position of idealism, Bertrand Russell was much interested in the place of the a priori in geometric knowledge. Russell's solution to this problem in his *Foundations of Geometry,* which was first published in 1897, is not among those permissible today. However, his insights, as well as his review of 19th century work in non-Euclidean geometry, remain valuable. Morris Kline has contributed a short but thorough foreword to the present edition.

Investigation on the Theory of the Brownian Movement. Albert Einstein. R. Furth, Ed. Translated by A. D. Cowper. Dover, New York, 1956. 122 pp. $1.25. (Unaltered republication of the translation first published in 1926).

The long argument about whether molecules really exist was finally clinched by Albert Einstein's explanation of the Brownian movement in terms of kinetic theory. This contribution is to be found in the second of the three great papers that Einstein published in 1905 and in four papers that he prepared shortly thereafter, three developing various details of the explanation and one offering a simplified exposition "welcomed by chemists." In 1926 the papers on the Brownian movement were translated into English, supplied with helpful footnotes, and published in a little volume, of which the present edition is a reprint.

Organization of the Federal Government for Scientific Activities. National Science Studies. National Science Foundation, Washington, D.C., 1956. 349 pp. $1.75 (order from Supt. of Documents, GPO, Washington 25).

The Federal Government's activities in the field of science have become so extensive that a report detailing the extent of each federal agency's interest and effort in this direction is timely and likely to be welcomed by many individuals and groups throughout the country. One of a series of National Science Studies being published by the National Science Foundation, *Organization of the Federal Government for Scientific Activities* presents recent and authoritative information concerning all aspects of scientific activity engaged in by the various organizational units of the 38 executive agencies that deal with scientific matters in one way or another.

Part I of the report deals with the development of federal organization and activity in the scientific area, and part II presents a concise and useful directory of the numerous departments, commissions, boards, committees, offices, bureaus, and so forth that carry out the Federal Government's activities in science.

Robert Hooke. Margaret 'Espinasse. University of California Press, Berkeley, 1956. vii + 192 pp. Illus. $3.75.

It is perhaps a measure of the wealth of talent that came forward in the age of the renaissance of science that a man who has been called "the most sanely imaginative of the early Fellows of the Royal Society" and "the most prolific inventor of his age," a man who made contributions as various as the demonstration of the cellular structure of plants and the invention of the universal joint, should have been heretofore given so little biographical attention. Hooke can hardly be called a "forgotten" scientist, as his name appears very frequently in books on the history of science and technology. But he is at best pictured as a minor scientist, and too frequently as an unattractive also-ran. The purpose of M. 'Espinasse is "to retrieve his character," but she does not forget, fortunately, that her readers

also need to be told the particulars of Hooke's scientific career. This career, which made important contributions to physiology, microscopy, astronomy, chemistry, mechanics, optics, horology, and architecture (to mention a nonexhaustive list) inevitably appears to have been that of a dilettante, when it is presented in general works. Here, seen as a whole, it becomes much more impressive.

Greater understanding of the controversial side of Hooke's character, especially his controversies with Newton and Hevelius and those over horological invention, has been possible since the publication of his diary in 1935. It may be that 'Espinasse goes too far in her rehabilitation of his reputation. Her judgment of Newton is harsh, and a rebuttal seems probable. Her judgment of Hooke's work in horology, however, is supported to a considerable degree by the most authoritative recent work on that subject. The chapters on his social and personal life assume an unusual importance in view of the personal character of much of the criticism of Hooke's scientific work.

It will be evident from its length that this is not a definitive biography of Hooke. Except by the professional historian, however, it should be no less appreciated, for its attractive format, style, and price should earn for it a wide circulation. It can be recommended not only to those who are interested in Hooke, but as an unusually graphic account of the scientific environment of that great age.

ROBERT P. MULTHAUF
Department of Engineering and Industries, Smithsonian Institution

Books Reviewed in SCIENCE

5 October

Science and Civilisation in China, vol. 2, *History of Scientific Thought,* J. Needham (Cambridge University Press). Reviewed by R. Multhauf.

Biology of the Laboratory Mouse, Staff of the Roscoe B. Jackson Memorial Laboratory, G. D. Snell, Ed. (Dover). Reviewed by D. Price.

Hormones and the Aging Process, E. T. Engle and G. Pincus, Eds. (Academic Press). Reviewed by J. T. Velardo.

Gmelins Handbuch der Anorganischen Chemie, System No. 60, *Copper,* pt. A, sec. 1 and sec. 2; Gmelin Institute, Eds. (Verlag Chemie). Reviewed by H. S. Sisler.

Proceedings of the Conference on Pathophysiologic and Therapeutic Problems of Terminal Conditions Associated with the Clinic and Practice of First Aid (U.S.S.R. State Publishing House of Medical Literature). Reviewed by S. A. Corson.

12 October

Chromosome Botany, C. D. Darlington (Allen & Unwin). Reviewed by K. Sax.

Report of the Special Committee on the Federal Loyalty-Security Program of the Association of the Bar of the City of New York (Dodd, Mead). Reviewed by R. A. Walker.

Medicinal Chemistry, vol. II, F. F. Blicke and C. M. Suter, Eds. (Wiley; Chapman & Hall). Reviewed by B. B. Brodie.

19 October

The International Dictionary of Physics and Electronics, W. C. Michels, Ed. (Van Nostrand; Macmillan). Reviewed by B. C. Dees.

E. A. Birge, a Memoir, G. C. Sellery (University of Wisconsin Press). Reviewed by R. W. Pennak.

Weather Analysis and Forecasting, vol. I, *Motion and Motion Systems; Weather Analysis and Forecasting,* vol. II, *Weather and Weather Systems,* S. Petterssen (McGraw-Hill). Reviewed by J. Spar.

Polysaccharides in Biology, G. F. Springer, Ed. (Josiah Macy, Jr. Foundation). Reviewed by M. H. Adams.

Bibliography of Solid Adsorbents, 1943–1953, V. R. Dietz (National Bureau of Standards). Reviewed by L. H. Reyerson.

Creatures of the Deep Sea, K. Günther and K. Deckert (Scribner). Reviewed by W. Beebe.

Advances in Enzymology and Related Subjects of Biochemistry, vol. 17. F. F. Nord, Ed. (Interscience). Reviewed by M. H. Adams.

Anatomy of the Honey Bee, R. E. Snodgrass (Comstock). Reviewed by R. Walker.

26 October

Fertilization, L. Rothschild (Methuen; Wiley). Reviewed by A. Tyler.

Physics and Mathematics, ser. I, *Progress in Nuclear Energy,* R. A. Charpie, J. Horowitz, D. J. Hughes, and D. J. Littler, Eds. (McGraw-Hill; Pergamon). Reviewed by R. L. Murray.

Progress in Neurobiology: I, Neurochemistry, S. R. Korey and J. I. Nurnberger, Eds. (Hoeber-Harper). Reviewed by S. S. Kety.

Handbook of Scientific and Technical Awards in the United States and Canada, M. A. Firth, Ed. (Special Libraries Association); *Alcoholism as a Medical Problem,* H. D. Kruse, Ed. (Hoeber-Harper). Reviewed by K. M. Bowman.

Handbuch der Physik, vol. 47, *Geophysics,* I. S. Flügge, Ed., J. Bartels, Group Ed. (Springer-Verlag). Reviewed by B. Gutenberg.

New Books

Behavior Theory and Conditioning. Kenneth W. Spence. Yale University Press; New Haven; Geoffrey Cumberlege, Oxford University Press, London, 1956. 262 pp. $4.50.

Technique of Organic Chemistry. vol. II, *Catalytic, Photochemical, and Electrolytic Reactions.* Arnold Weissberger, Ed. Interscience, New York, ed. 2, 1956. 543 pp. $11.50.

Science in Progress. Ninth Series. George A. Baitsell, Ed. Yale University Press, New Haven, Conn.; Geoffrey Cumberlege, Oxford University Press, London, 1956. 343 pp. $6.50.

Experimental Physical Chemistry. Farrington Daniels, Joseph H. Mathews, John W. Williams, Paul Bender, Robert Alberty. McGraw-Hill, New York, ed. 5, 1956. 482 pp. $6.50.

An Introduction to Modern Organic Analysis. Sidney Siggia and Hans J. Stolten. Interscience, New York, 1956. 250 pp. $4.50.

The Training of Sanitary Engineers. Schools and programs in Europe and in the United States. Milivoj Petrik. World Health Organization, Geneva, 1956 (order from Columbia University Press, New York). 151 pp. $4.

The Earth beneath Us. H. H. Swinnerton. Little, Brown, Boston, American ed. 1, 1956. 335 pp. $5.

Grasslands of the Great Plains. Their nature and use. J. E. Weaver and F. W. Albertson. Johnsen, Lincoln, Neb., 1956. 395 pp.

Clay and Clay Minerals. Proceedings of the Third National Conference on Clays and Clay Minerals. Publ. 395. National Academy of Sciences–National Research Council, Washington, 1955. 573 pp. $7.

High Energy Nuclear Physics, Proceedings of the Sixth Annual Rochester Conference. 3–7 Apr. 1956. Compiled and edited by J. Ballam, V. L. Fitch, T. Fulton, K. Huang, R. R. Rau, S. B. Treiman. Interscience, New York, 1956. $3.75.

Grinnell Workbook in Biology. Biology Staff, Grinnell College. Norman H. Russell, Jr., Ed. Burgess, Minneapolis, 1956. 56 pp. $1.75.

Chemistry of High Polymer Degradation Processes. Norman Grassie. Interscience, New York; Butterworths, London, 1956. 335 pp. $6.50.

Mathematics for Electronics, with Applications. Henry M. Nodelman and Frederick W. Smith. McGraw-Hill, New York, 1956. 391 pp. $7.

Applied Electrical Measurements. Isaac F. Kinnard. Wiley, New York; Chapman & Hall, London, 1956. 600 pp. $15.

Sleep. Marie C. Stopes. Philosophical Library, New York, 1956. 154 pp. $3.

Modern Views on the Secretion of Urine. Cushny Memorial Lectures. F. R. Winton, Ed. Little, Brown, Boston, 1956. 292 pp. $8.50.

Handbuch Der Physik. vol. XXII, *Gas Discharges.* S. Flügge, Ed. Springer, Berlin, 1956. 652 pp. DM. 128.

A Life of Sir William Ramsay. Morris W. Travers. Arnold, London, 1956. 308 pp. $12.50.

Fine Structure of Cells. A symposium held at the 8th Congress of Cell Biology, Leiden, 1954. Union Internationale des Sciences Biologiques; Interscience, New York, 1956. 321 pp. $8.50.

Corn and Its Early Fathers. Henry A. Wallace and William L. Brown. Michigan State University Press, East Lansing, 1956. 134 pp. $3.75.

Statistical Mechanics, Principles and Selected Applications. Terrell L. Hill. McGraw-Hill, New York, 1956. 432 pp. $9.

Bird and Butterfly Mysteries. The truth about migration. Bernard Acworth. Philosophical Library, New York, 1956. 303 pp. $7.50.

William Heytesbury. Medieval logic and the rise of mathematical physics. Curtis Wilson. University of Wisconsin Press, Madison, 1956. 219 pp. $4.

The Image. Kenneth E. Boulding. University of Michigan Press, Ann Arbor, 1956. 175 pp. $3.75.

Introductory Psychosomatic Dentistry. John H. Manhold, Jr. Appleton-Century-Crofts, New York, 1956. 193 pp.

How to Make and Use a Telescope. H. Percy Wilkins and Patrick Moore. Norton, New York, 1956. 196 pp. $2.95.

Polyethylene. vol. XI of *High Polymers.* R. A. V. Raff and J. B. Allison. Interscience, New York, 1956. 551 pp. $16.

Textbook of Biophysical Chemistry. Edward S. West. Macmillan, New York, ed. 2, 1956. 399 pp. $7.

Chemistry of Carbon Compounds. vol. III, pt. B, *Aromatic Compounds.* E. H. Rodd, Ed. Elsevier, Amsterdam-Princeton, 1956 (order from Van Nostrand, Princeton, N. J.). 1669 pp. $25.

The International Dictionary of Physics and Electronics. Walter C. Michels, Ed. Van Nostrand, Princeton, N. J.; Macmillian, London, 1956. 1004 pp. $20.

The Chemistry of the Coordination Compounds. John C. Bailer, Jr., Ed. Reinhold, New York; Chapman & Hall, London, 1956. 834 pp. $18.50.

Observations on Krebiozen in the Management of Cancer. A. C. Ivy, John F. Pick, W. F. P. Phillips. Regnery, Chicago, 1956. 88 pp. $2.50.

Supersonic Inlet Diffusers and Introduction to Internal Aerodynamics. Rudolf Hermann. Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., 1956. 378 pp. $16.

The Condensed Chemical Dictionary. Arthur and Elizabeth Rose. Reinhold, New York, and Chapman & Hall, London, ed. 5, 1956. 1201 pp. $12.50.

The New Outline of Modern Knowledge. Alan Pryce-Jones, Ed. Simon and Schuster, New York, 1956. 624 pp. $6.

Magnetochemistry. Pierce W. Selwood. Interscience, New York, ed. 2, 1956. 435 pp. $11.50.

Perspectives in Organic Chemistry. Alexander Todd, Ed. Interscience, New York, 1956. 527 pp. $7.50.

High Pressure Technology. Edward W. Comings. McGraw-Hill, New York, 1956. 572 pp. $11.50.

Latex, Natural and Synthetic. Philip G. Cook. Reinhold, New York; Chapman & Hall, London, 1956. 231 pp. $3.50.

Procedure in Taxonomy. Including a reprint in translation of the *Regles Internationales de la Nomenclature Zoologique.* With titles and notes on the opinions rendered to the present date (1907 to 1956). Edward T. Schenk and John H. McMasters. A. Myra Keen and Siemon William Muller, Eds. Stanford University Press, Stanford, Calif., ed. 3, 1956. $3.50.

An Introduction to Cell and Tissue Culture. By the Staff of the Tissue Culture Course, Cooperstown, New York, 1949–1953. Burgess, Minneapolis, 1955. 123 pp. $4.

INDEX TO VOLUME 83 (JULY–DECEMBER 1956)

[Note: In all divisions of this index, the letter (L) following a title indicates a letter to the editors.]

Title Index of Articles and Letters

AAAS affairs: AAAS building dedication, 213; AAAS finances: report for 1955, D. Wolfle, 220; AAAS New York meetings, 1887–1956, R. L. Taylor, 214; Academy grants for student research, J. A. Behnke, 55; Assistant director for STIP, 55; Courses for science and mathematics teachers, I. E. Wallen and J. R. Mayor, 217; Editor for journals, D. Wolfle, 55; General chairman for AAAS meeting, 107; Hotel headquarters and housing, New York meeting, 107; Junior academies of science, T. Heatwole, 219; Moving frontiers of science, 306; Preliminary announcement of the seventh New York meeting, R. L. Taylor, 48; Proposed change in AAAS Constitution, 300; Secondary-school enrollments, I. E. Wallen and J. R. Mayor, 218; Socio-psychological prize judges, 219; Some programs at the New York meeting, 307; STIP study on use of science counselors, J. R. Mayor, 56; Theobald Smith award, 55; Theobald Smith award judges, 219; Traveling high-school science libraries, 300

Caste and the Jajmani system in a north Indian village, O. Lewis and V. Barnouw, 66
Cattle raising: a way of life in the Venezuelan llanos, C. Langdon White, 122
Chemical research and education in Japan, B.-I. Tamamushi, 248

Documentation in the service of science (L), E. Garfield, 258

Features of the solar spectrum as imposed by the physics of the sun, R. N. Thomas, 135

Genetic principles in human populations, H. J. Muller, 277
Geomagnetic program of the International Geophysical Year, E. O. Hulburt, 87
Gravity program of the U.S. National Committee for the IGY, G. P. Woollard, 298

Hermann von Helmholtz: nineteenth-century polymorph, H. Gruber and V. Gruber, 92
Historical and thematic relations of psychology to other sciences, E. Brunswik, 151

Interindustry analysis, new tool in economics, J. H. Cumberland, 189
International Geophysical Year earth satellite program, H. E. Newall, Jr., 13

Man as a link in complex machine systems, G. H. Mowbray, 269
Meaning of protoplasm, The (L), R. Walker, 35
Michael Faraday's researches in spiritualism, 145

New interpretation of the surface of Mars, D. B. McLaughlin, 176

On going berserk: a neurochemical inquiry, H. D. Fabing, 232
Our vanishing sea turtles (L), C. Grant, 257

Path of atoms through generations, G. Hevesy, 238
Photosynthetic nitrogen fixation by blue-green algae, M. B. Allen, 100
Plane geometry and plain logic, N. A. Court, 28
Present growth and advance of Boulder Glacier (L), W. A. Long, 37
Protogenetics from Adam to Athens, L. P. Coonen, 57
Pseudonyms (L), R. C. Miller, 258
Pseudonyms of physicists, R. Lagemann, 130

Radiochemistry, W. F. Libby, 115
Radiological defense laboratory, 254

Science, humanities, and artifacts, H. Brown, 169
Seismology and the U.S. IGY program, A. P. Crary, 225
Social science techniques: a problem of power and responsibility, E. Gross, 242
Some notes on the ecology of ecologists, P. B. Sears, 22
Some peaceful uses of atomic energy, W. K. Davis, S. Warren, W. L. Cisler, 287
Studies on deep mass culture of algae in Israel, A. M. Mayer, A. Eisenberg, M. Evenari, 198

Technical information—too much or too little? S. Herner, 82
Tektites and the lost planet, R. Stair, 5

Validity of test items that involve finding a pattern in data: a rejoinder (L), R. H. Lampkin, 35

Author Index

Aberle, D. F., Book review, 111
Allen, M. B., Photosynthetic nitrogen fixation by blue-green algae, 100
Anderson, R., Book review, 167

Barnouw, V. *See* Lewis, O., 66
Behnke, J. A., Academy grants for student research, 55; Book review, 313
Berrill, N. J., Book review, 41
Berry, E. W., Book review, 42, 112, 263
Brown, H., Science, humanities, and artifacts 169
Brunswik E., Historical and thematic relations of psychology to other sciences, 151

Cameron, E. A., Book review, 205
Chafee, Z., Jr., Book review, 259
Charpie, R. A., Book review, 43
Cisler, W. L. *See* Davis, W. K., 287
Cohen, I. B., Book review, 109
Coonen, L. P., Protogenetics from Adam to Athens, 57
Corson, S. A., Book review, 164, 206
Court, N. A., Plane geometry and plain logic, 28
Crary, A. P., Seismology and the U.S. IGY program, 225
Cumberland, J. H., Interindustry analysis, new tool in economics, 189

Davis, W. K., Some peaceful uses of atomic energy, 287
de Laguna, F., Book review, 208

Eisenberg, A. *See* Mayer, A. M., 198
Evenari, M. *See* Mayer, A. M., 198

Fabing, H. D., On going berserk: a neurochemical inquiry, 232

Garfield, E., Documentation in the service of science (L), 258
Gault, H. R., Book review, 39, 112
Glass, B., Book review, 311
Gould, L. M., Book review, 210
Grant, C., Our vanishing sea turtles (L), 257
Gross, E., Social science techniques: a problem of power and responsibility, 242
Gruber, H., Hermann von Helmholtz: nineteenth-century polymorph, 92
Gruber, V. *See* Gruber, H., 92

Hardin, G., Book review, 40
Heatwole, T., Junior academies of science, 219
Hendricks, B. C., Book review, 42
Herner, S., Technical information—too much or too little? 82
Herzfeld, R. F., Book review, 264
Hevesy, G., Path of atoms through generations, 238
Hulburt, E. O., Geomagnetic program of the International Geophysical Year, 87

Koprowski, H., Book review, 110

Lagemann, R., Pseudonyms of physicists, 130
Lampkin, R. H., Validity of test items that involve finding a pattern in data: a rejoinder (L), 35
Lewis, O., Caste and the Jajmani system in a north Indian village, 66
Libby, W. F., Radiochemistry, 115
Llewellyn, F. J., Book review, 111
Long, W. A., Present growth and advance of Boulder Glacier (L), 37

Magee, J. L., Book review, 166
Mayer, A. M., Studies on deep mass culture of algae in Israel, 198
Mayor, J. R., STIP study on use of science counselors, 56; Book review, 263
Mayor, J. R. *See* Wallen, I. E., 217, 218
McLaughlin, D. B., New interpretation of the surface of Mars, 176
Mellon, M. G., Book review, 43
Miller, R. C., Pseudonyms (L), 258
Milne, L. J., Book review, 312
Milne M., Book review, 312
Moos, M. C., Book review, 163
Mowbray, G. H., Man as a link in complex machine systems, 269
Muller, H. J., Genetic principles in human populations, 277
Multhauf, R. P., Book review, 314

Newell, H. E., Jr., International Geophysical Year earth satellite program, 13

Palmer, C. A., Jr., Book review, 42
Prunty, M. C., Jr., Book review, 204

Ray, D. P., Book review, 311
Rose, H. M., Book review, 207
Rosen, E., Book review, 211
Rosenthal, A., Book review, 45

Saunders, J. B. DEC. M., Book review, 265
Sears, P. B., Some notes on the ecology of ecologists, 22
Singer, S. F., Book review, 44, 209
Spencer, R. F., Book review, 210
Stair, R., Tektites and the lost planet, 3
Straus, W. L., Jr., Book review, 209

Tamamushi, B.-I., Chemical research and education in Japan, 248
Taylor, R. L., Book review, 44; New York meetings of the AAAS, 1887–1956, 214; Preliminary announcement of the seventh New York meeting, 48
Thomas, R. N., Features of the solar spectrum as imposed by the physics of the sun, 135
Turner, J., Book review, 207, 310

Velardo, J. T., Book review, 162

Walker, R., The meaning of protoplasm (L), 35
Wallen, I. E., Courses for science and mathematics teachers, 217; Secondary-school enrollments, 218
Warren, S. *See* Davis, W. K., 287
White, C. L., Cattle raising: a way of life in the Venezuelan llanos, 122
Wolfle, D., AAAS finances: report for 1955, 220; Editor for journals, 55
Woollard, G. P., Gravity program of the U.S. National Committee for the IGY, 298

Yagoda, H., Book review, 310

Books Reviewed

Ackerknecht, E. H., *A Short History of Medicine,* 162
Allison, I. S. *See* Emmons, W. H., 112
Anderson, H. V., *Chemical Calculations,* 111
The Antarctic Challenged, E. R. G. R. Evans, 210
Asimov, I. *See* Boyd, W. C., 40
Atlas of Paleogeographic Maps of North America, C. Schuchert, 112
Atom Harvest, L. Bertin, 43
Auerbach, C., *Genetics in the Atomic Age,* 311

Bank, T., II, *Birthplace of the Winds,* 208
Barnett, H. G., *The Coast Salish of British Columbia,* 210
Beloshapko, P. A., *Hastening Childbirth without Pain,* 164
Bertin, L., *Atom Harvest,* 43
Birthplace of the Winds, T. Bank, II, 208
Blank, H., *Viral and Rickettsial Diseases of the Skin, Eye and Mucous Membranes of Man,* 110
Boyd, W. C., *Races and People,* 40
Bricker, C. E. *See* Willard, H. H., 43

Carnap, R. *See* Neurath, O., 313
Carr, A., *The Windward Road,* 41
Celebrated American Caves, C. E. Mohr and H. N. Sloane, 110
Chemical Calculations, H. V. Anderson, 111
Coast Salish of British Columbia, The, H. G. Barnett, 210
Cobb, B., *A Field Guide to the Ferns and Their Related Families of Northeastern and Central North America with a Section on Species also Found in the British Isles and Western Europe,* 312
Commissariat à l'Energie Atomique, *La Prospection de l'Uranium,* 42
The Condensed Chemical Dictionary, A. and E. Rose, 312

Demographic Yearbook 1955, Statistical Office of the United Nations, 265
Drucker, P., *Indians of the Northwest Coast,* 210
Dunnington, G. W., *Carl Friedrich Gauss: Titan of Science,* 205

Eastman, N. J. *See* Temkin, O., 265
Edelstein, L. *See* Temkin, O., 265
Einstein, A., *Investigation on the Theory of the Brownian Movement,* 314
Elements of Quantitative Analysis, H. H. Willard, N. H. Furman, C. E. Bricker, 43
Emmons, W. H., *Geology: Principles and Processes,* 112
Engel, L., Ed., *New Worlds of Modern Science,* 266
'Espinasse, M., *Robert Hooke,* 314
An Essay on the Foundations of Geometry, B. A. W. Russell, 314
Evans, E. R. G. R., *The Antarctic Challenged,* 210

Famous Problems and Other Monographs, F. Klein, W. F. Sheppard, P. A. MacMahon, L. J. Mordell, 45
A Field Guide to the Ferns and Their Related Families of Northeastern and Central North America with a Section on Species also Found in the British Isles and Western Europe, B. Cobb, 312
Foi, A. M. *See* Beloshapko, P. A., 164
Free Skin Grafting in Patients with Extensive Skin Defects, B. A. Petrov, 206
Fric, F. I. R., Ed., *Oeuvres de Lavoisier. Correspondance,* 211
Furman, N. H. *See* Willard, H. H., 43
Furth, R., Ed., *Investigation on the Theory of the Brownian Movement,* A. Einstein, 314

The Gardener's Bug Book, C. Westcott, 44
Gartmann, H., *The Men behind the Space Rockets,* 310
Carl Friedrich Gauss: Titan of Science, G. W. Dunnington, 205
Genetics in the Atomic Age, C. Auerbach, 311
Geology: Principles and Processes, W. H. Emmons, G. A. Thiel, C. R. Stauffer, I. S. Allison, 112
Gignoux, M., *Stratigraphic Geology,* 39
Gottmann, J., *Virginia at Mid-Century,* 204
Guided Missiles in War and Peace, N. A. Parson, Jr., 209
Guttmacher, A. F. *See* Temkin, O., 265

Hastening Childbirth without Pain, P. A. Beloshapko and A. M. Foi, 164
Heath, T. L., *The Thirteen Books of Euclid's Elements,* 112
Heineman, E. R., *Plane Trigonometry,* 263
Hertz, H., *The Principles of Mechanics,* 207
Hite, K. E. *See* Kelly, F. C., 207
Robert Hooke, M. 'Espinasse, 314
The Hopi Indians, H. C. James, 167

Illustrations of the Huttonian Theory of the Earth, J. Playfair, 263
Indians of the Northwest Coast, P. Drucker, 210
International Encyclopedia of Unified Science, O. Neurath, R. Carnap, C. Morris, Eds., 313
Investigation on the Theory of the Brownian Movement, A. Einstein, 314

James, H. C., *The Hopi Indians,* 167
Japanese National Commission for UNESCO, *Proceedings of the UNESCO Symposium on Typhoons, 9–12 November 1954, Tokyo,* 42
Jordan, P., *Science and the Course of History,* 109

Kelly, F. C., *Microbiology,* 207
Klein, F., *Famous Problems and Other Monographs,* 45

The Laws of Nature, R. E. Peierls, 310

MacMahon, P. A. *See* Klein, F., 45
Mallan, L., *Men, Rockets and Space Rats,* 44
Man, Culture, and Society, H. L. Shapiro, Ed., 264
Man and Energy, A. R. Ubbelohde, 166
McKean, E. C., *Public Works and Employment from the Local Government Point of View,* 311
The Men behind the Space Rockets, H. Gartmann, 310
Men Rockets and Space Rats, L. Mallan, 44
Microbiology, F. C. Kelly and K. E. Hite, 207
Mohr, C. E., *Celebrated American Caves,* 110
Mordell, L. J. *See* Klein, F., 45
Morris, C. *See* Neurath, O., 313

The Navajos, R. M. Underhill, 111
Neurath, O. Ed., *International Encyclopedia of Unified Science,* 313
New Worlds of Modern Science, L. Engel, Ed., 266

Oeuvres de Lavoisier. Correspondance, F. I. R. Fric, Ed., 211
Organization of the Federal Government for Scientific Activities, 314

Parson, N. A., Jr., Guided Missiles in War and Peace, 209
Peierls, R. E., *The Laws of Nature,* 310
Petrov, B. A., *Free Skin Grafting in Patients with Extensive Skin Defects,* 206
Sir William Petty, E. Strauss, 163
The Piltdown Forgery, J. S. Weiner, 209
Plane Trigonometry, E. R. Heineman, 263
Playfair, J., *Illustrations of the Huttonian Theory of the Earth,* 263
The Principles of Mechanics, H. Hertz, 207
Proceedings of the UNESCO Symposium on Typhoons, 9–12 November 1954, Tokyo, Japanese National Commission for UNESCO, 42
La Prospection de l'Uranium, Commissariat à l'Energie Atomique, 42
Public Works and Employment from the Local Government Point of View, E. C. McKean and H. C. Taylor, 311

Races and People, W. C. Boyd and I. Asimov, 40
Rake, G. *See* Blank, H., 110
Rayleigh, B. *See* Strutt, J. W., 265
Report of the Special Committee on the Federal Loyalty-Security Program of the Association of the Bar of the City of New York, 259
Rose, A., *The Condensed Chemical Dictionary,* 312
Rose, E. *See* Rose, A., 312
Russell, B. A. W., *An Essay on the Foundations of Geometry,* 314

Schuchert, C., *Atlas of Paleogeographic Maps of North America,* 112
Science and the Course of History, P. Jordan, 109
Shapiro, H. L., Ed., *Man, Culture, and Society,* 264
Sheppard, W. F. *See* Klein, F., 45
A Short History of Medicine, E. H. Ackerknecht, 162
Sloane, H. N. *See* Mohr, C. E., 110

Soranus' Gynecology, O. Temkin, N. J. Eastman, L. Edelstein, A. F. Guttmacher, 265
Statistical Office of the United Nations, *Demographic Yearbook 1955,* 265
Stauffer, C. R. *See* Emmons, W. H., 112
Stratigraphic Geology, M. Gignoux, 39
Strauss, E., *Sir William Petty,* 163
Strutt, J. W., *The Theory of Sound,* 265

Taylor, H. C. *See* McKean, E. C., 311
Temkin, O., *Soranus' Gynecology,* 265
The Theory of Sound, J. W. Strutt and B. Rayleigh, 265
Thiel, G. A. *See* Emmons, W. H., 112
The Thirteen Books of Euclid's Elements, T. L. Heath, 112

Ubbelohde, A. R., *Man and Energy,* 166
Underhill, R. M., *The Navajos,* 111

Viral and Rickettsial Diseases of the Skin, Eye and Mucous Membranes of Man, H. Blank and G. Rake, 110
Virginia at Mid-Century, J. Gottmann, 204

Weiner, J. S., *The Piltdown Forgery,* 209
Wendt, G., *You and the Atom,* 42
Westcott, C., *The Gardener's Bug Book,* 44
Willard, H. H., *Elements of Quantitative Analysis,* 43
The Windward Road, A. Carr, 41

You and the Atom, G. Wendt, 42

Analytic Subject Index

AAAS, academy grants for student research, 55; announcement of 1956 meeting of, 48; building dedication of, 213; chairman for 1956 meeting of, 107; changes in constitution of, 300; editor for journals of, 55; hotel headquarters and housing for 1956 meeting of, 107; new home for, 188; New York meetings of, 214; prizes of, 219; programs for 1956 meeting of, 306; financial report of, 220; Science Teaching Improvement Program of, 55; AAAS Socio-Psychological prize judges, 219; AAAS, Theobald Smith award, 55; traveling high-school library of, 300
Academies, junior, of science, 219
Aerobees, and International Geophysical Year, 13
Alaska, geomagnetic stations in, 90
Algae, blue-green, photosynthetic nitrogen fixation by, 100
Algae, mass culture of, 198
Algebra, matrix, and economics, 194
Altitude, study of high, 13
Amanita muscaria, in producing psychoses, 232
American Rocket Society, 14
Anabaena cylindrica, as blue-green algae agent, 100
Analogy, false, 173
Antarctic, and International Geophysical Year, 13
Antarctica, geomagnetic stations in, 90
Anthropology, and caste, 66
Archeology, and humanities, 170; and study of tektites, 3
Arctic, and International Geophysical Year, 13
Areology, 177
Artifacts, and science, 169
Asteroids, and study of tektites, 3
Astronomy, 135; and Mars, 176; and study of tektites, 3
Astrophysics, and International Geophysical Year, 13; and Mars, 176; and study of tektites, 3
Atmosphere, disturbances of, 227; of Mars, 178; and solar physics, 141; study of during IGY, 13
Atomic energy, and international cooperation, 294; in medicine, 293; peaceful uses of, 287; radiochemical aspects of, 116
Atoms, passage of, 238
Aurora, study, of during International Geophysical Year, 13
Australite, 3

Balloon, and International Geophysical Year, 13
Bediasite, 3
Behaviorism, classical, 157
Bell-Magendie law, 151
Berserksgang, 232
Billitonite, 4
Biophysics, and psychology, 157
Bone, phosphorus in human, 239
Botany, and neurochemistry, 232
Boulder Glacier, 37
Boyle, R., pseudonym of, 130
Brain, and intelligence, 152
Bufotenine, as a psychosis-producing agent, 233

Calcium, in human body, 239
Calendar, of Mars, 177
Caste system, in India, 66
Cattle raising, in Venezuela, 122
Chapman-Störmer current ring, 13
Chemical element, transuranic, 118
Chemical elements, on Mars, 178
Chemical Society of Japan, 248
Chemistry, hot-atom, 116; Japanese research in, 248; radiation, 118; and radiochemistry, 115
Chemists, radiochemical training for, 118
Chlorella, deep mass culture of, 198
Civilization, and caste, 66
Clock, world time, 241
Clocks, atomic, as contributions of radiochemists, 116
Comets, and tektites, 8
Communication, of technical information, 82; theory of, 160
Cosmic rays, study of during International Geophysical Year, 13
Cosmology, and International Geophysical Year, 13; and origin of tektites, 3; and radiochemistry, 116
Crater, lunar, in study of tektites, 3
Culture, and caste, 66; and science, 169
Curie, M., and radiochemistry, 115
Cytology, and genetic principles in human populations, 277; of mass culture of algae, 198

Darwin, and ecology, 22
Data, validity of test items for finding a pattern in, 35
Dating, radioactive, 116
Diamond, black, 3; man-made, 21
Documentation, scientific, 258; and technical information, 82
Drama, and science, 170
Duality, principle of, 28

Earth, and seismology, 225
Earth satellite, and International Geophysical Year, 13
Earth sciences, and the International Geophysical Year, 13
Earth's magnetic field, study of during International Geophysical Year, 13
Earthquakes, and IGY program, 225

Ecology, of ecologists, 22
Econometrics, 189
Economics, new tool in, 189; and psychology, 160
Education, in radiochemistry, 121
Energy, Helmholtz principle of conservation of, 156
Energy, solar, 100; and International Geophysical Year, 13
Environment, and genetics, 57

Faraday, M., and researches in spiritualism, 145
Folklore, and neurochemistry, 232

General Electric Research Laboratory, and synthetic diamonds, 21
Genetics, and ecology, 22; history of, 57; and human populations, 277; radioactivity effects in, 238
Geodesy, and International Geophysical Year, 13
Geography, of Venezuela, 122
Geologic dating, early use of radioactive tracers in, 115
Geology, and the gravity program of the IGY, 298; of Mars, 176; and radiochemistry, 115; and seismology, 225
Geomagnetism, and International Geophysical Year, 13, 87
Geometry, contributions of H. von Helmholtz to, 92
Geometry, plane, and plain logic, 28
Geophysics, and the gravity program of the IGY, 298; and research during International Geophysical Year, 13; and seismology, 225
Glacier activity, 37
Glaciology, and International Geophysical Year, 13
Glass, tektite, 3
Grasslands, in Venezuela, 122
Gravity program, and the IGY, 298
Guided missiles, and the International Geophysical Year, 13

Hafnium, discovery of, 115
Hahn, O., and radiochemistry, 115
Hall, A. R., 174
Helmholtz, H. von, 92; and conservation of energy, 156
Heredity, and caste, 66; and protogenetics, 57
Hevesy, G. von, and radiochemistry, 115
High school, traveling science library for, 300
History of science, 169; and geometry, 28; and H. von Helmholtz, 92; and protogenetics, 57; and pseudonyms, 130; and radiochemistry, 116
Holman, E., as general chairman of AAAS 1956 meeting, 107
Homeostasis, 157
Human being, and instrument design, 270; and machine systems, 269; and passage of atoms, 238; phosphorus in, 239; study of individual, 169
Human populations, genetic principles in, 277
Humanities, and ecology, 22; and science, 169
Humor, in scientific writing, 130
Hybridization, early experiments with, 57
Hydrodynamics, Helmholtz' contributions to, 97

India, and caste system, 66; ecological research in, 23
Indochinite, 4
Industry, and atomic power, 287; Venezuela cattle, 122
Input-output economics, 190
Instrument design, psychology of, 270
Instrumentation, and International Geophysical Year, 13
Intelligence, and brain, 152
Interindustry economics, 189
International cooperation, in atomic energy, 294
International Geophysical Year, geomagnetic program of, 87; gravity program of, 298; satellite program of, 13; and seismology, 225
International Union of Geodesy and Geophysics, 14
International Union of Scientific Radio, 14
Iodine, chemistry of recoil atom of, 117
Isomerism, nuclear, 116
Israel, mass culture of algae in, 198

Jajmani, as an Indian caste system, 66
Japan, chemical research and education in, 248
Junior academies of science, 219

Kelvin, Lord (William Thomson), pseudonym of, 132
Keynes, J. M., 189

Langur, white-mouthed, 65
Leontief, W., and economics, 190
Lind, S. C., and investigation of ionized molecules from chemical viewpoint, 118
Literature, anonymous, in science, 130; in relation to science, 169
Llanos, in Venezuela, 122
Lobachevski, N. I., and Euclidean geometry, 28
Lodge, O., pseudonym of, 134
Logic, and plane geometry, 28
Logistics, and International Geophysical Year, 13

Machine systems, 269
Mars, new interpretation of surface of, 176; surface of, 161
Mathematics, and biophysics, 157; courses for teachers of, 217; and economics, 190; Helmholtz' contributions to, 97; and logic, 28
Maxwell, J. C., pseudonym of, 134
Measurement, and International Geophysical Year, 13
Medicine, atomic energy in, 293
Mendel's law, and ecology, 22
Mercantilists, and economics, 189
Meteor Crater, in study of tektites, 8
Meteorite, and study of tektites, 3
Meteorology, and psychology, 160; and study of tektites, 3
Meteors, and study of tektites, 3
Micrometeorite, 13
Microseisms, 227
Milky Way, in study of tektites, 3
Moldavite, 3
Monkey, leaf-eating, 65
Moon, artificial, and International Geophysical Year, 13
Mushroom eating, and neurochemistry, 232
Mythology, and neurochemistry, 232

National Institute for Ecological Research, 23
Naval Research Laboratory, and International Geophysical Year, 13
Neurochemistry, and mythology, 232
Nitrogen fixation, by blue-green algae, 100
Nomenclature, for protoplasm, 35
Nuclear reactor, kinds of, 287

Observatories, magnetic, and the IGY, 87
Ocean, on Mars, 182
Oceanography, and International Geophysical Year, 13
Ophthalmoscope, Helmholtz' invention of, 92
Organic synthesis, application of hot-atom chemistry to, 117
Orogeny, 176

Osler, W., pseudonym of, 131

Pacific islands, geomagnetic stations in, 91
Pangenesis, 57
Pascal, B., *Pensées* of, 169; pseudonym of, 131
Pen names, of scientists, 130
Pendulum measurements, and gravity program of the IGY, 298
Philosophy, and ecology, 22; and geometry, 28; and psychology, 153
Phosphorus, in human body, 239
Physicists, pseudonyms of, 130, 258
Physics, Helmholtz' contributions to, 97; and psychology, 156; and radiochemistry, 115; solar, 13
Physiology, Helmholtz' contributions to, 92; and psychology, 151
Planetoid, and study of tektites, 3
Polar years, 13
Poncelet, J. V., and projective geometry, 28
Population studies, and genetic principles, 277
Propulsion system, and earth satellite, 13
Protogenetics, 57
Protoplasm, meaning of, 35
Pseudonyms, of physicists, 130, 258
Psychiatry, and genetic principles in human populations, 277; and psychology, 155
Psychical phenomena, kinds of, 145
Psychoanalysis, and psychology, 156
Psychology, of instrument design, 270; related to other sciences, 151

Radioactive materials, early work on, 115; in human body, 238
Radiochemistry, 115
Radioisotopes, availability of, 120
Radiological defense laboratory, 254
Radon, in investigation of ionized molecules, 118
Research, during International Geophysical Year, 13; technical information and market, 82; social control of, 242
Rice, blue-green algae as fertility agent to, 100
Rizalite, 3
Rocket, high-altitude, and International Geophysical Year, 13
Rubidium-strontium method of dating, 115

Satellite *See* Earth satellite
Savannas, in Venezuela, 122
Schizophrenia, as related to bufotenine, 235
Science, courses for teachers of, 217; philosophy of, 130; and psychology, 155; related to humanities and artifacts, 169; unity of, 152; universality of, 13
Science Teaching Improvement Program, assistant director for, 55; and study on use of science counselors, 56
Scientific method, 169; and Helmholtz, 92
Scientific priorities, 19th-century controversies over, 94
Scientific and technical information, 82
Scientific writing, humor in, 130
Scientists, pen names of, 130; responsibility of, 242
Seasonal changes, on Mars, 186
Secondary-school, enrollment in, 218
Seismology, and International Geophysical Year, 13, 225
Sex determination, historical interest of, 57
Skeleton, phosphorus in human, 239
Smithsonian Institution, and synthetic diamonds, 21
Social science, and economics, 189; techniques of, 242
Socio-economics, in India, 66; in Venezuela, 122
Sociology, techniques in, 242
Sodium, in human body, 238
Solar batteries, and International Geophysical Year, 13
Solar energy, 135; and supply of nitrogen, 100
Solar physics, 135
Solar prominences, 140
Solar system, and study of tektites, 3
Spectral transmittances, in study of tektites, 3
Spiritualism, researches of Faraday in, 145
Sun, and International Geophysical Year, 13; physics of, 135
Sunspot, and International Geophysical Year, 13

Taine, H., 174
Tait, P. G., pseudonym of, 132
Teachers, courses for science and mathematics, 217
Teaching, of radiochemistry, 118
Technique, of mass culture of algae, 198; in social science, 242
Technology, and economics, 193
Tektites, 3
Test items, and finding a pattern in data, 35
Theobald Smith award judges, 219
Theory, of tektites, 3; volcanic-aeolian, 176
Thermodynamics, of sun, 137
Thomson, W. (Lord Kelvin), pseudonym of, 132
Thurber, J., 175
Time, clock for world, 241
Time-clocks, geologic, as contributions of radiochemists to geology and cosmology, 116
Transportation, Venezuelan need for, 123
Turtles, preservation of sea, 257

Universe, and study of tektites, 3
Urbanization, and ecology, 22
U.S. Atomic Energy Commission, and radioisotopes, 120
U.S. Coast and Geodetic Survey, 89
U.S. Department of Defense, and International Geophysical Year, 13
U.S. National Committee for IGY, 14
U.S. Naval Radiological Defense Laboratory, 254

Venezuela, cattle industry of, 122
Vision, Helmholtz' contributions to color, 92
Volcanic-aeolian theory, of Mars, 176

Water, in animal body, 240
Weber-Fechner law, 151
Wind, on Mars, 183
World time clock, 241

Young, T., pseudonym of, 131

An invitation to engineers who can qualify for large, liquid propellant Rocket Engine development

Engineers and Scientists:

PRELIMINARY DESIGN. Opportunity to conceive, analyze, and evaluate highly advanced concepts in large, liquid-propellant rocket engines, advanced propellants, feed systems, principal components and parameters. Advanced military proposals. Market studies. Operations Research and long-range programming. Advanced degrees preferred.

SYSTEMS ANALYSIS. Unusual challenges for the analytical or theoretical engineer in the analysis of complete engine systems. Heavy emphasis on advanced Systems Engineering concepts, particularly in thermodynamics, gas dynamics, heat transfer and fluid flow, some phases of which are yet unknown in general industry. Prediction of engine performance, by means of advanced mathematical concepts, under extreme environmental operating conditions.

COMBUSTION DEVICES. Important professional growth opportunities for engineers heavy on thermodynamic and heat transfer background, as it may pertain to high temperature, high stress components such as thrust chambers, gas generators, injectors, and heat exchangers. Unusual challenges available in work on high-rate heat transfer, pyrotechnics, spark-initiated and hypergolic ignition, combustion mechanics, droplet formation and flame propagation.

ENGINE DEVELOPMENT. Opportunities for research engineers at the focal point of intensive activity associated with engine testing and data evaluation. Involves the design of experiments, specification of test methods and procedures, including instrumentation, as well as the processing and evaluation of data. Problems and studies encountered fall into all branches of engineering, and the ability to comprehend highly complex systems, engines and engine programs is of paramount importance.

RESEARCH. Rocketdyne Research, a section of the Engineering department, has several staff openings for scientists and engineers with advanced abilities. Fundamental studies are being made in thermodynamics, fluid mechanics, combustion kinetics, fast-transient measurement techniques, propellant chemistry and many other fields.

For detailed information, please fill out and mail the coupon below. There is no obligation, and all replies are strictly confidential.

Mr. A. W. Jamieson, Rocketdyne Engineering Personnel Dept. 11-SM
ROCKETDYNE, 6633 Canoga Avenue, Canoga Park, California

Dear Mr. Jamieson:

Please tell me more about a career at ROCKETDYNE.

My name is _____

Home Address _____

I have a _____ degree from _____

And _____ years actual engineering experience

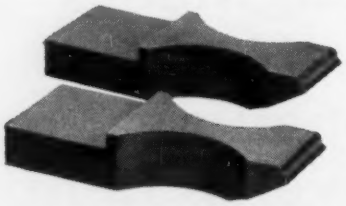
I am

I am not enclosing a resume

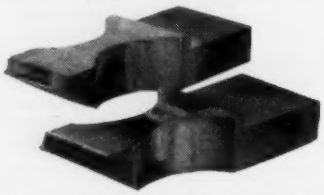
ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.

BUILDERS OF POWER FOR OUTER SPACE



New Kentanium pinch-off jaws.



Kentanium jaws after pinching and sealing over 215,000 tubes. Note the small amount of wear on this set.

KENTANIUM* jaws pinch off and seal HOT glass tubing at 1500°F to 1700°F

Jawlife increased ten-fold

To provide a tight seal for vacuum purposes, glass tubing is pinched off and sealed with pinch jaws made of Kentanium, a heat-resistant titanium alloy that retains great strength and resists abrasion at high temperatures.

Formerly, pinch jaws of alloy steel or chrome carbide were used. To prevent the hot glass in a semi-plastic state (1500°F to 1700°F) from sticking to the jaws, powdered graphite was used as a lubricant. After the pinch-off, an extra glazing operation was necessary to *completely seal* the tubes to retain vacuum. Life of jaws: only 20,000 to 25,000 tubes.

As the non-galling characteristic of Kentanium is effective in glass forming operations (when in semi-plastic state), it was applied and the need for a lubricant during the pinch-off operation was eliminated. The extra glazing operation also was eliminated because Kentanium produced a clean, tightly-sealed pinch-off. Results: life of Kentanium jaws average 215,000 tubes.

This is just another example of how Kennametal* compositions help engineers to solve problems requiring metals which have high resistance to heat, abrasion, corrosion, deflection, deformation, galling or impact. Perhaps you have such a problem. Then we invite you to write KENNAMETAL INC., Dept. MS, Latrobe, Pennsylvania. One of the many Kentanium or Kennametal compositions may provide the answer.

*Trademarks of a series of hard carbide alloys of tungsten, tungsten-titanium, and tantalum.

INDUSTRY AND
KENNAMETAL
...Partners in Progress

MISSILE SYSTEMS

ELECTRONICS

Significant developments at Lockheed Missile Systems Division have created new openings for engineers and physicists in fields related to: UHF and microwave receivers; antennas; radomes; countermeasures; radar systems; propagation; circuit techniques; radar reflectivity; guidance; semi-conductor and magnetic amplifiers. *Inquiries are invited about positions in these fields.* Please address the Research and Engineering Staff at Van Nuys.

Lockheed

MISSILE SYSTEMS DIVISION

LOCKHEED AIRCRAFT CORPORATION

VAN NUYS • PALO ALTO • SUNNYVALE

CALIFORNIA

THE FUTURE OF ARID LANDS

A symposium volume of the American Association for the Advancement of Science

Edited by Gilbert F. White

Department of Geography, University of Chicago

6 x 9 inches, 464 pages, 49 illustrations, index, clothbound, October 1956

Price $6.75. AAAS Members' prepaid order price $5.75

The volume presents the efforts of scientists from 17 countries and from as many disciplines to assess the state of man's struggle to make productive and stable use of the world's arid lands.

It contains the papers and recommendations of the International Arid Lands Symposium and Conference, Albuquerque and Socorro, New Mexico, April and May 1955.

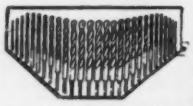
The symposium develops around a few basic questions. The representation and treatment of the subjects are highly interdisciplinary and lead to some important conclusions. The breadth and scope are indicated by the groupings of the Conference recommendations: Anthropology, Archaeology and Geography; Meteorology and Climatology; Hydrology, Geology and Soils; Biology, Ecology and Conservation; Organization, Communication, and Interdisciplinary Programs. Workers in all these fields, as well as administrators of government and private programs, will find the contents of this volume both stimulating for ideas and invaluable as a source of information.

British Agents—Bailey Bros. & Swinfen, Ltd., 46 St. Giles High Street, London

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

1515 Massachusetts Avenue, N.W., Washington 5, D.C.

29-Pc. Chrome Vanadium Drill Set



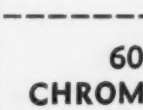
Specially made for speed drilling. In sturdy plastic tool roll. Finest alloy steel drills hardened and precision ground to the sharpest, longest lasting cutting edge obtainable; will easily and cleanly bite through hard-woods, plastics, aluminum, iron and the toughest steels. Unconditionally guaranteed for thousands of drillings. Full jobber length. Sizes by 64th from 1/16" to 1/2". There are only a limited quantity of sets available at this low price, so hurry!

$6.49 ppd.

Also available with Turned Down Shanks to fit all 1/4" drills. In individual pocket roll.

$8.95 ppd.

60 Pc. Set Wire Gauge CHROME VANADIUM DRILLS



Top quality high test Chrome Vanadium Drills designed for speed drilling through toughest steels, woods, plastic, iron and aluminum. Precision ground, long-lasting cutting edges. Guaranteed to give years of satisfaction. A full 60 pc. set nos. 1 through 60.

A $14.95 value— NOW ONLY $5.40
plus 35¢ pp. & hdlg.

Same set above available with Huot Index container $6.65
plus 35¢ pp. & hdlg.

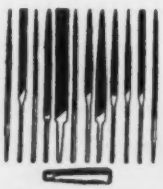
75¢ ea. for Finest Quality Imported PRECISION PLIERS

FOR JEWELERS, OPTICAL WORKERS, HOBBYISTS, CRAFTSMEN OF ALL KINDS!

These superb German instruments are of deep-forged, heat-treated high quality tool steel, fabricated to most exacting specifications. All-over ground and polished to smooth hard surfaces. Smooth working joints with just right tension. Jaws meet perfectly to safely and securely hold even the most delicate objects in hard-to-reach corners and angles. Each plier is 4" long and a veritable gem of precision and strength.

75¢ each **all 7 for $5.00 ppd.**

12 Pc. Needle & Warding FILE SET ONLY



$2.49 (plus 25¢ hdlg. & pstg.)

Made from the best quality tool steel, to fit the exacting requirements of mechanics, watch and jewelry craftsmen, hobbyists. Attractive kit contains the following 5½" long needle and warding files with high test cutting qualities: round, flat, knife, square, triangular. In all textures: fine, medium fine, medium, medium coarse, coarse. Comes with polished wood handle and new type steel grip chuck.

Minimum order $1.00. Send Check or M.O. C.O.D. plus fee. Money Back Guarantee.

SCOTT-MITCHELL HOUSE, INC.
Dept. 7112, 611 Broadway, New York 12, N. Y.

The Society for the Advancement of General Systems Theory announces the publication of

GENERAL SYSTEMS

(The Yearbook of the Society)

Ludwig von Bertalanffy and Anatol Rapoport, editors.

Contents of Volume 1 (1956)

Part I. INTRODUCTION

General System Theory Ludwig von Bertalanffy
General System Theory—the Skeleton of Science Kenneth Boulding
Definition of System A. D. Hall and R. E. Fagan

Part II. EXPLORATION OF MATHEMATICAL MODELS

Mathematical Models in the Social Sciences Kenneth J. Arrow
The Diffusion Problem in Mass Behavior Anatol Rapoport
Behavior: Imbalance in a Network of Chemical Transformations . D. F. Bradley and M. Calvin
Toward a General Theory of Growth Kenneth Boulding
The Principle of Allometry in Biology and the Social Sciences Raoul S. Naroll and Ludwig von Bertalanffy
On the Parallel between Learning and Evolution J. W. S. Pringle

Part III. IN SEARCH OF NEW FOCI OF INTEGRATION

The Hypothesis of Cybernetics .. J. O. Wisdom
Topology and Life: In Search of General Mathematical Principles in Biology and Sociology N. Rashevsky
Dynamic Systems, Psychological Fields, and Hypothetical Constructs ..... David Krech
Dynamic Systems as Open Neurological Systems David Krech
A Biologist's View of Society .... R. W. Gerard
The Rights of Man: a Biological Approach R. W. Gerard

Price per volume $7.50. Orders received by Braun-Brumfield, Inc., P.O. Box 203, Ann Arbor, Michigan

Subscriptions free to members of the Society. Address inquiries about membership to Professor Ludwig von Bertalanffy, Mount Sinai Hospital 8720 Beverly Boulevard, Los Angeles 48, California.

Just Published!

Heredity and Your Life

by Dr. A. M. Winchester

Prof. of Genetics, Stetson U., DeLand, Fla.

An authoritative presentation of human heredity in a form that will appeal to layman and scholar alike. This new work should prove an important milestone in bridging the gap between the discoveries of the specialists and the understanding of the general public. The section on radiation, mutations, and the atomic age is an important and timely discussion which should be read by everyone, especially world leaders who must make decisions on the use of nuclear weapons and atomic energy. Profusely illustrated with photographs and diagrams. 336 pages. Price: $5.00

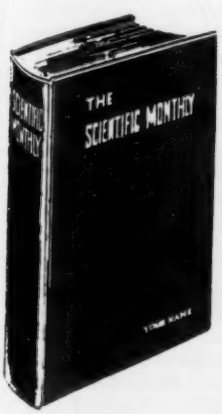
At your bookseller's or from the publisher

VANTAGE PRESS, INC.
120 West 31 Street New York 1, N. Y.

TO AUTHORS
seeking a publisher

Learn how we can publish, promote and distribute your book on a professional, dignified basis. All subjects considered. Scholarly and scientific works a specialty. Many successes, one a best seller. Write for booklet SM—it's free.

VANTAGE PRESS, Inc. • 120 W. 31 St., N.Y. 1
In Calif.: 6253 Hollywood Blvd., Hollywood 28
In Wash., D.C.: 1010 Vermont Ave., NW



Preserve your SM copies for quick, easy reference with attractive

<< BINDERS

$3 each; add 50¢ postage for orders outside U.S.A. (Name, 75¢ extra; year, 50¢ extra.) Personal check or money order, please!

The SCIENTIFIC MONTHLY 1515 Mass. Ave., NW Washington 5, D. C.

Special Discount to Members of the American Association for the Advancement of Science

Proceedings of the Third Berkeley Symposium on Mathematical Statistics and Probability

University of California Press, Berkeley and Los Angeles, 1956

Vol. I. *Contributions to the Theory of Statistics*

Contributors: Joseph Berkson; Z. W. Birnbaum; Herman Chernoff and Herman Rubin; Aryeh Dvoretzky; Sylvain Ehrenfeld; G. Elfving; Ulf Grenander and Murray Rosenblatt; J. L. Hodges, Jr., and E. L. Lehmann; Wassily Hoeffding; Samuel Karlin; L. Le Cam; Herbert Robbins; Murray Rosenblatt; Charles Stein; B. L. Van der Waerden.

Cloth. List Price $6.00
Publication Date: 18 August 1956

Vol. II. *Contributions to Probability Theory*

Contributors: David Blackwell; Salomon Bochner; K. L. Chung; A. H. Copeland, Sr.; J. L. Doob; Robert Fortet; J. M. Hammersley; T. E. Harris; Kiyosi Itô; Paul Lévy; Michel Loève; Eugene Lukacs; Karl Menger; Edith Mourier; R. Salem and A. Zygmund.

Cloth. List Price $6.50
Publication Date: 10 October 1956

Vol. III. *Contributions to Astronomy and Physics*

Contributors: Olin J. Eggen; Jesse L. Greenstein; Harold L. Johnson; Gerald E. Kron; Bengt Strömgren; G. C. McVittie; Jerzy Neyman, Elizabeth L. Scott and C. D. Shane; F. Zwicky; André Blanc-Lapierre and Albert Tortrat; M. Kac; J. Kampé de Fériet; Elliot Montroll; Norbert Wiener.

Cloth. List Price $6.25
Publication Date: 1 June 1956

Vol. IV. *Contributions to Biology and Problems of Health*

Contributors: James F. Crow and Motoo Kimura; Everett R. Dempster; Jerzy Neyman, Thomas Park and Elizabeth L. Scott; M. S. Bartlett; A. T. Bharucha-Reid; Chin L. Chiang, J. L. Hodges, Jr., and J. Yerushalmy; Jerome Cornfield; David Kendall; William F. Taylor.

Cloth. List Price $5.75
Publication Date: 5 June 1956

Vol. V. *Contributions to Econometrics, Industrial Research, and Psychometry*

Contributors: Kenneth J. Arrow and Leonid Hurwicz; Edward W. Barankin; C. West Churchman; Patrick Suppes; Albert H. Bowker; Cuthbert Daniel; Milton Sobel; T. W. Anderson and Herman Rubin; Frederick Mosteller; Herbert Solomon.

Cloth. List Price $5.75
Publication Date: 30 June 1956

By a special arrangement, members of the AAAS may purchase any or all of the five volumes at a 25-percent discount. To obtain this discount, orders must be sent to the Statistical Laboratory, University of California, Berkeley 4, California. They must refer to membership in the AAAS and be accompanied by checks for the correct amount. Checks should be made payable to the University of California Press.

Meetings

December

26–31. American Assoc. for the Advancement of Science, annual, New York, N.Y. (R. L. Taylor, AAAS, 1515 Massachusetts Ave., NW, Washington 5.)

The following 55 meeting will be held in conjunction with the AAAS annual meeting.

AAAS Academy Conference (L. Taylor, West Virginia Univ., Morgantown). 29–30 Dec.

AAAS Cooperative Committee on the Teaching of Science and Mathematics (M. Meister, Bronx High School of Science, New York 68). 27 Dec.

AAAS-Gordon Research Conferences (W. G. Parks, Univ. of Rhode Island, Kingston). 27 Dec.

Alpha Chi Sigma (H. G. Seavey, 30 Church St., Room 340, New York 7). 28 Dec.

Alpha Epsilon Delta (M. L. Moore, 7 Brookside Circle, Bronxville, N.Y.). 29 Dec.

American Assoc. of Clinical Chemists (A. E. Sobel, Jewish Hospital of Brooklyn, Brooklyn 16).

American Assoc. of Hospital Consultants (E. D. Barnett, School of Public Health, Columbia Univ., New York 32).

American Assoc. of Scientific Workers (R. J. Rutman, 6331 Ross St., Philadelphia 44, Pa.). 29 Dec.

American Astronomical Soc. (J. A. Hynek, Harvard College Observatory, Cambridge 38, Mass.). 26–29 Dec.

American Documentation Inst. (J. Hilsenrath, National Bureau of Standards, Washington 25). 27–29 Dec.

American Educational Research Assoc. (A. G. Wesman, Psychological Corp., 522 Fifth Ave., New York 36). 29 Dec.

American Meteorological Soc. (R. J. Roth, Crop-Hail Insurance Actuarial Assoc., 209 W. Jackson Blvd., Chicago, Ill.). 28 Dec.

American Museum of Natural History (G. Reekie, AMNH, Central Park West at 79 St., New York, N.Y.). 26 Dec.

American Nature Study Soc. (R. L. Weaver, Univ. of Michigan, Ann Arbor). 26–30 Dec.

American Philosophical Assoc., Eastern Div. (J. Wild, Harvard Univ., Cambridge 38, Mass.). 27 Dec.

American Psychiatric Assoc. (B. Pasamanick, Ohio State Univ., Columbus 10). 28–29 Dec.

American Soc. of Hospital Pharmacists (G. E. Archambault, U.S. Public Health Service, Washington 25). 29 Dec.

American Soc. of Range Management (F. G. Renner, Soil Conservation Service, U.S. Dept. of Agriculture, Washington 25). 28 Dec.

American Statistical Assoc. (R. E. Johnson, Western Electric Co., New York 7, N.Y.).

Association for Computing Machinery (J. P. Nash, Univ. of Illinois, Urbana).

Association of American Geographers (P. M. Stern, Conservation Foundation, 30 E. 40 St., New York, N.Y.).

Astronomical League (H. B. Davidson, 812 Park Ave., New York 21, N.Y.).

Conference on Scientific Editorial Problems (J. G. Adashko, Ford Instrument Co., Long Island City, N.Y.). 26–28 Dec.

Conference on Scientific Manpower (T. J. Mills, National Science Foundation, Washington 25). 26 Dec.

Ecological Soc. of America (M. F. Buell, Rutgers Univ., New Brunswick, N.J.). 26–30 Dec.

Entomological Soc. of America (P. W. Oman, Plant Industry Sta., Beltsville, Md.). 27–30 Dec.

Genetics Soc. of America (A. W. Pollister, Columbia Univ., New York 27). 28 Dec.

History of Science Soc. (Pearl Kibre, Hunter College, New York, N.Y.). 27–29 Dec.

Honor Soc. of Phi Kappa Phi (L. R. Guild, 634 So. Western Ave., Los Angeles 5, Calif.). 28–29 Dec.

Institute of Mathematical Statistics (Miss E. Scott, Univ. of California, Berkeley 4).

International Council for Exceptional Children (M. H. Fouracre, Columbia Univ., New York 27). 26 Dec.

International Union for the Study of Social Insects, North American Section (T. C. Schneirla, American Museum of Natural History, Central Park West at 79 St., New York, N.Y.). 26–27 Dec.

Mountain Lake Biological Station (B. D. Reynolds, Univ. of Virginia, Charlottesville).

Mycological Soc. of America (L. S. Olive, Columbia Univ., New York 27). 26 Dec.

National Acad. of Economics and Political Science (D. P. Ray, George Washington Univ., Washington, D.C.). 27 Dec.

National Assoc. for Gifted Children (Miss A. F. Isaacs, 409 Clinton Springs Ave., Cincinnati, Ohio).

National Assoc. for Research in Science Teaching (N. Washton, Queens College, Flushing 67, L.I., N.Y.). 27 Dec.

National Assoc. of Biology Teachers (J. Breukelman, State Teachers College, Emporia, Kan.). 26–30 Dec.

National Assoc. of Science Writers (J. E. Pfeiffer, New Hope, Pa.).

National Geographic Soc. (W. R. Gray, NGS, 16 and M Sts., NW, Washington 6). 29 Dec.

National Speleological Soc. (Brother G. Nicholas, La-Salle High School, Cumberland, Md.). 29 Dec.

New York Acad. of Sciences (R. F. Nigrelli, New York Zoological Soc. and M. Kopac, New York Univ., Washington Sq., New York, N.Y.). 29 Dec.

Philosophy of Science Assoc. (C. W. Churchman, Case Inst. of Technology, Cleveland, Ohio). 29–30 Dec.

Pi Gamma Mu (B. H. Williams, Industrial College of the Armed Forces, Washington 25). 26 Dec.

Scientific Research Soc. of America (D. B. Prentice, Yale Univ., New Haven, Conn.). 26–27 Dec.

Sigma Delta Epsilon (C. Chandler, Boyce Thompson Inst. for Plant Research, Yonkers 3, N.Y.).

Sigma Pi Sigma (M. W. White, Pennsylvania State Univ., University Park).

Society for the Advancement of Criminology (D. E. J. MacNamara, New York Inst. of Criminology, 2109 Broadway, New York, N.Y.). 29 Dec.

Society for the Advancement of General Systems Theory (L. von Bertalanffy, Mt. Sinai Hospital, Los Angeles 48, Calif.). 29–30 Dec.

Society for the Study of Evolution (H. Lewis, Univ. of California, Los Angeles 24). 27–29 Dec.

Society of General Physiologists (A. Shanes, National Institutes of Health, Bethesda, Md.).

Society of Systematic Zoology (R. E. Blackwelder, Box 500, Victor, N.Y.). 27–30 Dec.

Society of the Sigma Xi (T. T. Holme, Yale Univ., New Haven, Conn.). 27 Dec.

Society of Vertebrate Paleontology, annual (J. T. Gregory, Peabody Museum of Natural History, Yale Univ., New Haven, Conn.). 28–30 Dec.

Torrey Botanical Club (D. Keck, New York Botanical Garden, Bronx Park, New York 58, N.Y.). 26–27 Dec.

United Chapters of Phi Beta Kappa (C. Billman, PBK, 1811 Q St., NW, Washington 6). 27 Dec.

27–28. Fluid Mechanics in Chemical Engineering, American Chemical Soc., Lafayette, Ind. (W. E. Ranz, Dept. of Engineering Research, Pennsylvania State Univ., University Park.)

27–28. Linguistic Soc. of America, Philadelphia, Pa. (A. A. Hill, Box 7790, University Sta., Austin 12, Tex.)

27–29. American Mathematical Soc., 63rd annual, Rochester, N.Y. (J. H. Curtiss, AMS, 80 Waterman St., Providence 6, R.I.)

27–29. American Physical Soc., Monterey, Calif. (W. A. Nierenberg, Univ. of California, Berkeley 4.)

27–29. Western Soc. of Naturalists, annual, Goleta, Calif. (D. Davenport, Santa Barbara College, Goleta.)

27–30. American Economic Assoc., annual, Cleveland, Ohio. (J. W. Bell, 629 Noyes St., Evanston, Ill.)

27–30. American Finance Assoc., annual, Cleveland, Ohio. (G. E. Hassett, Jr., New York Univ., 90 Trinity Pl., New York 6, N.Y.)

28. Society for the Advancement of Criminology, annual western, Fresno, Calif. (W. Dienstein, Fresno State College, Fresno.)

28–29. American Folk-Lore Soc., annual, Santa Monica, Calif. (MacE. Leach, Bennett Hall, Univ. of Pennsylvania, Philadelphia 4.)

28–30. American Anthropological Assoc., annual, Santa Monica, Calif. (W. S. Godfrey, Jr., Logan Museum, Beloit College, Beloit, Wis.)

28–30. American Historical Assoc., annual, St. Louis, Mo. (AHA, Study Room 274, Library of Congress, Washington 25.)

28–30. Archaeological Inst. of America, annual, Philadelphia, Pa. (C. Boulter, Library, Univ. of Cincinnati, Cincinnati 21, Ohio)

28–30. Industrial Relations Research Assoc., Cleveland, Ohio. (E. Young, Sterling Hall, Univ. of Wisconsin, Madison 6.)

29. Mathematical Assoc. of America, 40th annual, Rochester, N. Y. (H. M. Gehman, Univ. of Buffalo, Buffalo 14, N.Y.)

29–30. American Chemical Soc., Div. of Industrial and Engineering Chemistry, Princeton, N.J. (A. H. Emery, ACS, 1155 16 St., NW, Washington 6.)

January

7–11. International Social Science Council, 3rd general assembly, Paris, France. (Secretary General, ISSC, 19, avenue Kleber, Paris 16.)

10. Technical and Clinical Applications of Radioisotopes, Assoc. of Vitamin Chemists, Chicago, Ill. (M. Freed, Dawe's Laboratories, Inc., Chicago 32.)

10–12. American Group Psychotherapy Assoc., 14th annual, New York, N. Y. (C. Beukenkamp, Jr., AGPA, Room 300, 345 E. 46 St., New York 17.)

14–16. Cottonseed Processing as related to the Nutritive Value of the Meal, 4th conf., New Orleans, La. (Southern Regional Research Lab., USDA, 1100 Robert E. Lee Blvd., New Orleans 19.)

DICTIONARY OF ANTHROPOLOGY

by CHARLES WINICK

Prepared with the cooperation of a group of distinguished anthropologists

ANTHROPOLOGISTS in the course of their research are called upon to invent special terms. Many of these terms cannot be defined with absolute precision and are used on the basis of a tacit consensus about their meanings. This agreement depends on a shared notion of the connotations of a particular term rather than on a clear verdict of the words' denotation.

Many anthropological terms carry the burden of their past history into present discourse. Kroeber and Kluckhohn have written a fascinating and sizable monograph on the many shades of meaning which cluster around so basic an anthropological concept as "culture." In other cases, the meaning of a concept is affected by the distinctive circumstances of a classic investigation or the special use to which the concept was put by a particular investigation, or it is overlaid with the remains of past polemics.

Although no attempt has been made to cover every isolated use of a term, the selection of entries has been keyed to standard source and instructional materials in anthropology. To assist the reader into the more remote reaches of the literature, short biographical identifications of some of the leading earlier contributors to anthropology are included. $10.00

MAIL THIS COUPON TODAY

Mail to your favorite bookseller or directly to
PHILOSOPHICAL LIBRARY, Publishers
15 East 40th St., Desk 548, New York 16, N. Y.
Send ..... copies of "Dictionary of Anthropology" at $10.00 per copy.
Enclose remittance to expedite shipment.

NAME .....

ADDRESS .....

APPLICATION FOR HOTEL RESERVATIONS

123rd AAAS MEETING

New York City, December 26-31, 1956

The list of hotels and their rates and the reservation coupon below are for your convenience in making your hotel room reservation in New York. Please send your application, *not* to any hotel directly, but to the AAAS Housing Bureau in New York and thereby avoid delay and confusion. (Members of the American Astronomical Society who wish reservations at uptown hotels should correspond directly with the Hayden Planetarium.) The experienced Housing Bureau will make assignments promptly; a confirmation will be sent you in two weeks or less. **As in any city, single-bedded rooms may become scarce; double rooms for single occupancy cost more; for a lower rate, share a twin-bedded room with a colleague.** Most hotels will place comfortable rollaway beds in rooms or suites at 2.50 or 3.00 per night. Mail your application *now* to secure your first choice of desired accommodations. All requests for reservations must give a definite date and estimated hour of arrival, and also probable date of departure.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

All hotels have sessions in their public rooms. For a list of headquarters of each participating society and section, please see *Science*, July 20, or *The Scientific Monthly* for August.

Rates for Rooms with Bath*

Hotel	Single	Double Bed	Twin Bed	Suite
Governor Clinton	$7.00–11.00	$10.00–13.00	$11.00–17.00	$20.00–35.00
Martinique	5.00– 9.00	8.00–14.00	8.00–14.00	16.00–38.00
New Yorker	7.00–10.00	10.00–14.00	11.50–17.00	25.00 and up
Sheraton-McAlpin	6.75– 9.75	9.75–12.75	10.75–13.75	20.00 and up
Statler	8.00–12.00	11.00–15.00	11.50–18.00	31.00–33.00

* Subject to 5% New York City tax on hotel rooms.

---------- THIS IS YOUR HOUSING RESERVATION COUPON ----------

AAAS Housing Bureau
90 East 42nd Street
New York 17, N. Y.

Date of Application .....

Please reserve the following accommodations for the 123rd Meeting of the AAAS in New York City, Dec. 26–31, 1956:

TYPE OF ACCOMMODATION DESIRED

Single Room ..... Desired Rate ..... Maximum Rate .....
Double-Bedded Room ..... Desired Rate ..... Maximum Rate ..... Number in Party .....
Twin-Bedded Room ..... Desired Rate ..... Maximum Rate .....
Suite ..... Desired Rate ..... Maximum Rate ..... Sharing this room will be:

(Attach list if this space is insufficient. The name and address of each person, including yourself, must be listed.)

.....

.....

First Choice Hotel ..... **Second Choice Hotel** ..... **Third Choice Hotel** .....

DATE OF ARRIVAL ..... DEPARTURE DATE .....
(These must be indicated—add approximate hour, a.m. or p.m.)

NAME .....
(Individual requesting reservation) **(Please print or type)**

ADDRESS .....
(Street) **(City and Zone)** **(State)**

Mail this now to the Housing Bureau. **Rooms will be assigned and confirmed in order of receipt of reservation.**

OPTICAL BARGAINS — EXCELLENT FOR CHRISTMAS GIFTS!

See the Stars, Moon, Planets Close Up!

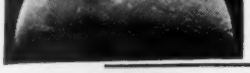
ASSEMBLE A BIG 100 POWER, 3" REFLECTING TELESCOPE

. . . with This Complete 87 Piece "Do-It-Yourself" Kit

Everything you need! No machining! Easily assembled! We furnish complete, simple instructions. Kit includes: 3" f/10 aluminized and overcoated Spherical Mirror—60X Eyepiece and 100X Barlow Lens—Cross-line Finder—sturdy 40" Tripod—fork type Equatorial Mount with locks on both axes—ventilated 3" Mirror Mount—heavy wall, black Telescope Tube. All nuts and bolts supplied. Nothing extra to buy. Our 3" spherical mirror (30" f.l.) is guaranteed to resolve detail right up to theoretical limit. Your finished scope can also be used terrestrially. Money back guarantee. Shipping weight 10 lbs.—**FREE with Kit: Valuable STAR CHART and 136-page book, "DISCOVER THE STARS"!**

Photographers!

Adapt your camera to this Scope for excellent Telephoto shots and fascinating photos of moon! Shown below is an actual photograph of the moon taken through our Astronomical Telescope by a 17 year-old student.



Stock #85,025-X $29.50 f.o.b., Barrington, N.J.

A "CLOSE-OUT" BARGAIN SPECIAL 7 x 50 MONOCULAR

This is fine quality, American made instrument—war surplus! Actually ½ of U. S. Govt. 7 x 50 Binocular. Used for general observation both day and night . . . to take fascinating telephoto shots. Brand new. $95 value. Due to Japanese competition we close these out at a bargain price.

Stock No. 50,003-X ..... $15.00 Pstpd.

50-150-300 POWER MICROSCOPE

Low Price Yet Suitable for Classroom Use!

Only $14.95

3 Achromatic Objective Lenses on Revolving Turret!

Imported! The color-corrected, cemented achromatic lenses in the objectives give you far superior results to the single lenses found in the microscopes selling for $9.95! Results are worth the difference! Fine rack and pinion focusing.

Stock No. 70,008-X ..... $14.95 Pstpd.

MOUNTED 500 POWER OBJECTIVE

. . . Threaded for easy attachment on above microscope. Achromatic lenses for fine viewing. 3 mm. focal length.

Stock #30-197-X ..... $5.00 Pstpd.

New! 2 in 1 Combination!
Pocket-Size
50 POWER MICROSCOPE and 10 POWER TELESCOPE
ONLY
$4.50 ppd.

Useful Telescope and Microscope combined in one amazing, precision instrument. Imported! No larger than a fountain pen. Telescope is 10 Power. Microscope magnifies 50 Times. Sharp focus at any range. Handy for sports, looking at small objects, just plain snooping.

Order Stock #30,059-X $4.50 ppd.

Send Check or M.O. Satisfaction Guaranteed!

MEASURING MAGNIFIER

For Checking Inspecting, Measuring

6 power magnification. Size 2" x 1". Extremely accurate right out to edge of field. Reticle pattern etched *on glass* for permanence. Positively not a cheap film reticle. Linear dimensions in decimal inches from 0 to ½" in steps of .005". mm scale from 0 to 10mm in steps of .2mm. Measures thicknesses from .002" to .007". Holes from .005" dia. to .050". Instrument comes in protective, genuine leather case.

Stock #30,169-X complete (no extras to buy) .... $12.50 Pstpd.

$12.50 Pstpd.

ULTRA HIGH POWER—20 x 60 BINOCULARS

A most unusual buy. See miles and miles away. Exceptionally large objective lenses—almost 2½" diameter—provide amazing light-gathering qualities—bright, crystal clear, sharply defined viewing. Individual focus eyepieces. Leather case and neck strap included. Mfgd. by a high grade producer in Japan—a domestic counterpart would cost several times the price. Full money-back guarantee.

Stock #1536-X ..... $75.90 Pstpd.

SIMPLE LENS KITS!

Fun for adults! Fun for children! Kits include plainly written, illustrated booklet showing how you can build lots of optical items.

Stock No. 2-X—10 lenses	$ 1.00	Postpaid
Stock No. 5-X—45 lenses	$ 5.00	Postpaid
Stock No. 10-X—80 lenses	$10.00	Postpaid

FUN WITH OPTICS

New booklet. 32 pages. Completely illustrated. Shows you how to build many types of optical instruments plus lens primer showing various types of lenses and how they work. Gives directions for building astronomical telescopes, terrestrial telescopes, artists drawing projectors, reflexslide viewers, magnifiers, miniature monoculars, transparency projectors, etc.

Stock #9050-X

$.50 postpaid

NEW! BUILD A SOLAR ENERGY FURNACE!

A fascinating new field. You can build your own Solar Furnace for experimentation—many practical uses. It's easy—inexpensive. We furnish instruction sheet. This sun powered furnace will generate terrific heat—produces many unusual fusing effects. Sets paper aflame in seconds.

Stock #80,040-X .. Fresnel Lens, size 11¾" x 16½"—f.l. 19" $3.50 Postpaid

NEW! STATIC ELECTRICITY GENERATOR

See a thrilling spark display as you set off a miniature bolt of lightning. Absolutely safe and harmless—perfect for classroom experimentation . . . ideal for science clubs. Sturdily made—stands 14" high. Turn the handle and two 9" plastic discs rotate in opposite directions. Metal collector brushes pick up the static electricity, store it in the Leyden jar type condenser until discharged by the jumping spark. Countless tricks and experiments. 24 Page Instruction booklet included.

Stock No. 70,070-X ..... $10.95 Postpaid

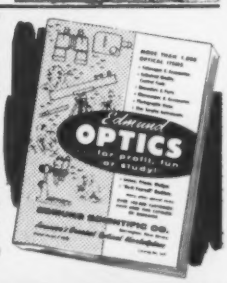
SPITZ MOONSCOPE

A precision-made 32 power reflecting telescope—by the makers of Spitz Planetarium. Clearly reveals the craters of the moon, shows Saturn, Jupiter, other wonders of the heavens. Based on same principles as world's giant telescopes. Stands 36" high on removable legs. Adjustable 3" polished and corrected mirror. Fork type Alt-Azimuth rotates on full 360° circle—swings to any location in the sky. Fascinating 18-page instruction book is included. Instrument packed in sturdy carrying case.

Stock No. 70,068-X ..... $14.95 Postpaid

GET OUR GIANT FREE CATALOG-X

Over 1000 Optical Bargains
64 Fascinating Pages



Huge selection of lenses, prisms, war surplus optical instruments, parts and accessories. Telescopes, microscopes, binoculars. Hand spectroscopes, reticles, mirrors, Ronchi rulings, dozens of other hard-to-get optical items. America's No. 1 source of supply for Researchers, Lab. Technicians, Photographers, Hobbyists, Telescope Makers, etc. Ask for catalog X.

ORDER BY STOCK NUMBER . SEND CHECK OR MONEY ORDER . SATISFACTION GUARANTEED!

EDMUND SCIENTIFIC CO., BARRINGTON, NEW JERSEY

GUIDED MISSILE
RESEARCH and DEVELOPMENT

A major guided missile research and development program has several significant characteristics that are of particular interest to the scientist and engineer.

First, it requires concurrent development work in a number of different technical areas such as guidance and control, aerodynamics, structures, propulsion and warhead. Each of these large areas in turn contains a wide variety of specialized technical activities. As an example, digital computer projects in the guidance and control area involve logical design, circuit design, programming, data conversion and handling, component and system reliability, input-output design, and environmental and mechanical design.

A second characteristic is frequently the requirement for important state-of-the-art advances in several of the technical areas. For instance, the supersonic airframe needed for a new missile may necessitate not only novel theoretical calculations, but also the design and performance of new kinds of experiments.

A third characteristic of missile development work is that such close interrelationships exist among the various technical areas that the entire project must be treated as a single, indivisible entity. For example, what is done in the guidance portion of the system can affect directly what must be done in the propulsion and airframe portions of the system, and vice versa.

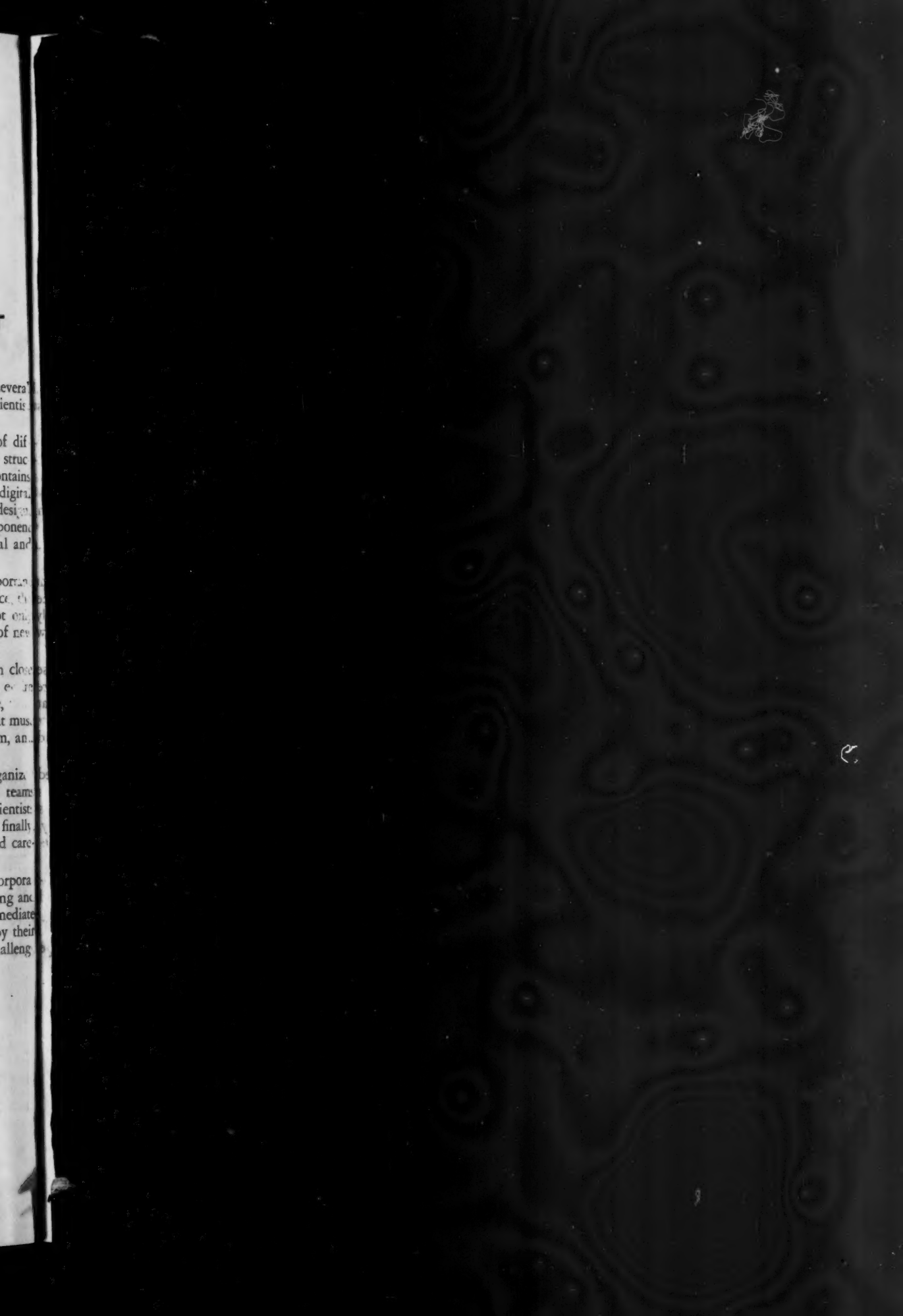
These characteristics make it clear why such work must be organized around strong teams of scientists and engineers. Further, for such teams to realize their full potential, they must be headed by competent scientists and engineers to provide the proper technical management. And finally, all aspects of the organization and its procedures must be tailored carefully to maximize the effectiveness of the technical people.

Principles such as these have guided The Ramo-Wooldridge Corporation in carrying out its responsibility for overall systems engineering and technical direction for the Air Force Intercontinental and Intermediate Range Ballistic Missiles. These major programs are characterized by their importance to the national welfare and by the high degree of challenge they offer to the qualified engineer and scientist.

6071

Openings exist for scientists and engineers in these fields of current activity:

Guided Missile Research and Development
Aerodynamics and Propulsion Systems
Communications Systems
Automation and Data Processing
Digital Computers and Control Systems
Airborne Electronic and Control Systems

The Ramo-Wooldridge Corporation

5730 ARBOR VITAE STREET • LOS ANGELES 45, CALIFORNIA